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CLIMATE AND COMPLEXION.*

By J. M. BUCHAN, M. A.

THERE is a great diversity of opinion as to the reason of the differences of complexion to be observed among mankind. Roughly speaking, the hue of the skin varies with the latitude, the fairer races having their homes at a distance from the equator; the darker, within or near the tropics. This fact would seem to point to the position of the sun with reference to those on whom he shines as the cause. But the question presents difficulties which this supposition does not aid us to solve.

At the same distance from the equator we find the fair Englishman, the yellow Mongol, and the copper-colored Indian. To the north of the white Russian and Finn live the swarthy Lapp and Samoyed. North of the Caucasus are dark-skinned Tartars, south of it fair-complexioned Circassians. The aborigines of America vary less in color than the natives of the Old World. None of them are as fair as the Swede, none as black as the negro of Congo, and those living in Brazil on the equator are not the darkest. There are blacker men in Australia and New Guinea than in Borneo and Sumatra, though these islands are on the equator and those are not. The Shillooks of the Upper Nile, who live about 10° north latitude, are blacker than the Monbuttoo who are six degrees farther south.

Many attempts have been made to explain these and similar facts. It has been asserted that mountaineers are fairer than lowlanders in the same latitude. This is generally the case, but there are some striking exceptions to the rule. The natives of the Mexican plateaus are as brown as those of the coast, and the Aymaras and Quichuas of

* This paper embodies the substance of a communication made to the Canadian Institute, Toronto, at a recent meeting.

the Peruvian Andes are darker than the Yuracaras of the forests to the east. The inhabitants of the Altai Mountains are yellow ; those of the plains of European Russia, at the same distance from the equator, white. According to Foissac, the blackness of the negro is a consequence of his vegetable diet, by which his blood is overloaded with carbon. But this theory, likewise, breaks down when submitted to the test of a comparison with the facts. The nomads of the Asiatic deserts, who live mainly on milk and flesh, are certainly not fairer than the grain-eating peasants whom they plunder ; and the Buddhists of China and Japan, whose religion prohibits the use of animal food, do not differ in color from their neighbors of other creeds. The influence of humidity has attracted the attention of some writers. Sir R. Schomburgk and M. d'Orbigny hold that it tends to lighten, Dr. Livingstone and others that it tends to darken, the hue. I shall state below my reasons for agreeing with the former.

Mr. Charles Darwin, Professor Huxley, M. Quatrefages, and others, think it probable that racial distinctions owe their origin to the selective operation of the prevailing diseases of particular climates. Assuming, what is amply supported by facts, that individuals slightly diverging in various directions from the type are constantly being produced, it is obvious that if a dark or a light complexion be correlated with power to resist a particular disease, or group of diseases, a white race may, by natural selection, be gradually developed from a colored one, or *vice versa*. M. Quatrefages has suggested that the malarial fevers of Africa have wrought this effect there, and that phthisis has been the agent in the north of Europe. It certainly is the case that the tropical regions of Africa are very unhealthy for whites, and that the negro dies out north of the parallel of 40° in both hemispheres ; but this does not show that both races might not be acclimatized by slow degrees without loss of color. In other words, no reason has been shown for thinking that it is to the complexion and not to some other racial peculiarity that the relative immunity from certain maladies is due. To connect the color with this immunity is the object of this paper.

I may say at the outset that I do not attach much importance to the direct influence of climatic conditions. It is, indeed, a matter of common observation that these produce considerable effects on the individual. Pruner, for example, states that he has noticed that "the European acclimated in Egypt acquires after some time a tawny skin, and in Abyssinia a bronzed skin ; he becomes pallid on the coast of Arabia, cachectic white in Syria, clear brown in the deserts of Arabia, and ruddy in the Syrian mountains."* But there is no proof that these cutaneous changes are inherited. If, however, it can be shown that a particular kind of skin is better than others for withstanding certain obvious weakening influences of a given climate, it stands to

* Waitz, "Anthropology."

reason that those members of a race whose skins vary in the direction of this type will in each generation have the best chance of surviving and begetting children, and that, by the continued increment of successive variations in the same direction, the skin and the climate will ultimately be brought into accord.

The skin consists of two layers: the inner, dense and fibrous, furnished with blood-vessels and nerves, called the dermis, or true skin; the outer, horny, nerveless, and bloodless, called the epidermis, cuticle, or scarf-skin. The cells which compose the latter originate in the *rete Malpighii*, its lowest part, are gradually forced outward by new cells, and finally exfoliate. In some of these epidermic cells a pigment is found which varies in different races, but always contains a yellow element. The hue of the skin does not depend on this coloring matter alone, but is a compound effect, resulting from the white of the dermis, the red of the blood in the minute vessels near the surface, the color and quantity of the pigment, and the thickness of the cuticle. Where the cuticle is thick, the color of the pigment will predominate over the other elements on account of the greater depth of pigment-cells. Where it is thin, and the coloring matter light, the tint of the skin will be much affected by any change in the supply of blood to the capillaries at the surface of the body. This is the reason why the whites alone can turn pale and blush.

Closely related to the pigment of the skin are the coloring matters of the eye and hair. Dark-skinned people usually have black eyes and hair; fair hair and blue eyes are seldom found except in conjunction with a fair skin; and the eyes and hair of albinoes, in whom the pigment of the skin is wanting, are likewise destitute of coloring matter. The pink hue of their eyes is due to minute blood-vessels, whose color is masked in ordinary organs by the pigment of the iris.

It is noteworthy that the coloring matters of the epidermis and iris serve a very important purpose: they protect the tender underlying parts from the injurious effects of too much heat and light. Albinoes everywhere find it necessary to protect their skins and eyes from the effects of the sun's rays. In warm countries they seldom go out except at night. There is this difference between them and other men, that long-continued exposure to the sun, which ordinarily develops a condition of the skin capable of resisting its rays, does not do so in their case. It may here be remarked that the deeper the shade of the pigment, the more rays will it reflect, and the more effective will it be as a protective agency. On the contrary, the lighter the shade, the more light and heat will it permit to enter the body.

As an excretory organ, it is the function of the skin to discharge water, carbonic acid, and urea—the first in large, the others in small quantities. Perspiration, or the excreting of water, with some saline matter in solution, is effected in two ways: In the first place, sudoriparous glands, imbedded in the true skin, secrete sweat from the blood.

This is conveyed to the air by minute ducts passing through the epidermis. It is obvious that, the blacker the pigment, the less light and heat will be transmitted to excite these glands into activity. In the second place, there is a continual transudation of sweat from the minute vessels of the surface of the body through the epidermis at every point. The thicker or the more oily the scarf-skin, the less will the amount of this transudation be. If it be both thick and oily, as in many dark races, the quantity transuded will be reduced to a minimum; if it be thin and not oily, as in the fairest members of the white race, transudation will be copious.

The amount of transuded sweat depends, however, not merely on the thinness of the cuticle, but also on the degree to which the air in contact with the body is saturated with moisture; for there is a limit to the quantity of vapor which the air can absorb. This limit varies with the temperature, warm air absorbing more than cold. Such being the nature of the skin, I now proceed to inquire what kind of it will best suit particular regions. For this purpose climates may be classified as—

I. Arctic.
II. Temperate humid.
III. Temperate dry.
IV. Tropical humid.
V. Tropical dry.

I. When the skin is exposed to great cold, perspiration by transudation is accelerated. The frosty air, raised many degrees in temperature by contact with the body, becomes very dry, and greedily drinks in its moisture. At the same time the body loses, not only the heat which the air carries off, but also that which is rendered latent by the evaporation of the sweat. As a protection against the injury which a too rapid loss of perspiration and heat may inflict in an arctic climate, a thick integument is desirable. On account of the obliquity of the sun's rays a dark pigment will be a disadvantage, because it will prevent the passage of light and heat. Some pigment will, however, be needed, as not even in northern regions can albinoes expose themselves to sunlight with comfort. The coloring matter, then, will be light; but, owing to the thickness of the cuticle, the general effect will be yellow.

II. By a humid temperate climate I mean one occurring in a temperate zone, in which the air constantly contains a large amount of moisture. Humidity does not to any considerable extent depend on the amount of the annual rainfall. The annual rainfall of London is twenty and one half inches, that of Toronto thirty inches; yet the air of the former place is incomparably more humid. Countries in which this climate is found are distinguished from others in the same latitude by the limited range of the thermometer. This is due partly to the fact that water can not be so rapidly heated as air, and partly to the check which the presence of haze, mist, or cloud in the atmosphere puts upon radiation. A humid temperate climate is also warmer than others in the same latitude, for it owes its existence in every case to breezes from warm seas. Breezes from cold seas can not produce a true humid temperate climate, because when they strike the land in summer they will be raised in temperature and rendered dry.

In humid temperate climates, since the rays of the sun, falling obliquely through a moisture-laden atmosphere, lose much of their light and heat, a dark pigment is a disadvantage. The vapor-clogged air tends to prevent perspiration, therefore a thin epidermis is desirable. The combination of a thin epidermis with a light pigment will give a fair complexion.

III. By a dry temperate climate I mean one occurring in a temperate zone in which the atmosphere is usually dry. Countries in which this climate prevails are distinguished from others in the same latitude by the great range of the thermometer. Their summers are hot and their winters cold. As a protection against the greater heat and brightness of the sun, a darker pigment than that which serves the purpose in humid temperate regions is necessary. To prevent the too rapid withdrawal of the fluid contents of the capillaries by the dry air, a thick cuticle is required. The combination of a thick cuticle with the pigment suitable to the intensity of the sun's rays will produce various shades of yellow and brown.

IV. By a humid tropical climate I mean one occurring in or near the torrid zone, in which there is no dry season. In such a climate vegetation will be luxuriant all the year round, and man will live in the shade of dense forests, in a steaming and enervating atmosphere, whose temperature will be high, but will vary little. Though the rays of the sun will descend vertically upon him, yet their power will be diminished by the vapor contained in the air, and he will not need so dark a pigment to protect him as the inhabitants of other tropical regions. Add to this, that a thin epidermis will promote perspiration which the moisture-laden atmosphere tends to check, and we come to the conclusion that the natives of such countries will be distinguished by comparatively fair complexions.

V. On the contrary, in a rainless tropical climate, or in one with a well-marked dry season, the rays of a vertical sun will continually, or for considerable periods, descend in all their power, and the blackest and densest pigment and the thickest scarf-skin will be needed. Between the tropics the nights are always long, and, in consequence, when in the dry season there is little moisture in the air to check radiation, the thermometer, as many African travelers have remarked, falls very low before sunrise. To withstand the loss of heat at such times a thick outer skin will be an advantage. Accordingly, in these climates, we find the blackest men and very thick skins.

This theory of the relations between the climate and the skin is, I believe, in accord with the facts. The polar tribes are known to be yellow. Among them, more frequently than elsewhere, according to Quatrefages, occur cases of dry, rough skins. This I take to be a result of the thickness of the cuticle, just as, on the older parts of a tree, the roughness of the bark is a consequence of its thickness.

It is well known that the climate of Europe, where white men most abound, is more influenced by the sea than that of any other continent. With the inconsiderable exception of the Caspian and Arctic regions, where yellow men occur, it may all be said to be kept moist by breezes from warm tracts of water. The fairest members of the human family are found in the humid lands about the North and Baltic Seas, where the influence of the Gulf Stream is most felt, and where a temperate climate extends farther from the equator than elsewhere on the face of the globe. When we proceed eastward from the Baltic, the complexions gradually darken as the increasing range of the thermometer indicates increasing dryness. Moscow, Kazan, and Tomsk are all near the fifty-sixth parallel of north latitude. The difference between the temperatures of the warmest and coldest months at these places is respectively 53°, 61°, and 69° Fahr. At Moscow, the population consists of fair- and dark-haired whites. About Kazan, though there are still fair and dark whites, there are also yellow men. At Tomsk the entire native population belong to the yellow race.

That the climate of the whole of Asia, from the Hindoo-Koosh and Himalaya Mountains northward, may be considered dry, is shown by the extensive deserts and the great range of temperature in the countries where sufficient rain falls to render agriculture possible. For instance, in China and Japan the range of the thermometer is somewhat greater than in corresponding latitudes in the eastern United States. The entire population of this vast area is yellow, with insignificant exceptions on its western border.

The greater part of North America corresponds in climate with central and eastern Asia. But the meteorological phenomena of the coast of British Columbia and Alaska are similar to those of the northwest of Europe. Warm winds from the Pacific keep the temperature high and the air moist; but, owing to the configuration of the coast and the direction of the mountain-ranges, their influence does not extend far inland. The immense difference between the climatic conditions of the eastern and western coasts of America may be illustrated by comparing the temperatures of Sitka (57° 3′ N. L.) and Quebec (46° 49′ N. L.). Though the latter is more than ten degrees farther south, its mean annual temperature is two degrees less, and, while the difference between the means of the warmest and coldest months is fifty-seven degrees at Quebec, it is only twenty-five at Sitka.

It is a fact which strikingly corroborates the theory advanced in this paper, that it is precisely in the northwestern part of this continent that the fairest natives are found. The testimonies of the early explorers, which have been collected and arranged by Mr. Bancroft, of San Francisco, in his valuable work on the Indians of the Pacific coast, leave no doubt that, before there was any intermixture of European blood in this region, the complexion of the inhabitants was not very different from that of southern Europeans, that their skins transmitted a blush, and that fair and brown hair, ruddy cheeks, and light eyes were not uncommon among them.

Perhaps the best example of a perpetually humid tropical climate is afforded by the valley of the Amazons. In consequence, nearly the whole of the vast region drained by this stream is, like some parts of India and some of the East Indian islands, covered with a dense unbroken forest. Though heated by an equatorial sun, its natives are, not only not black, but, as has already been remarked, lighter-complexioned than those of the Peruvian Cordilleras.

Examples of perpetually dry tropical climates are furnished by the Nubian Desert and the southern part of the Sahara. These countries, together with southern Arabia, enjoy the hottest mean summer temperature known. The inhabitants, whether belonging to the Semitic, the Hamitic, or the negro race, are alike black. The Nubian Arabs are said to be as black as the blackest negroes.

The part of Africa south of the Great Desert will exemplify the case of a tropical climate with a dry season. This immense region consists essentially of a strip of low coast-land, and an immense level central depressed surface, with a more or less elevated rim inclosing it. The inhabitants of the coast and the central depression are very black, those of the rim lighter in color. Dr. Livingstone attributes this difference to the greater humidity of the lower regions. But it is obvious, from theoretical considerations, that the rim must be more humid than any other part of the continent. During the dry season the sea-breezes, when they strike the coast, will be raised in temperature, and consequently deposit no moisture, until cooled by being forced upward when they come against some elevated land. The meteorological observations made in Africa support this view. Along the coast there is everywhere one pronounced dry season, and in some places there are two. In Sierra Leone (8° N. L.), it lasts from November to May; at the mouth of the Gaboon (0°), from May to September. In Zanzibar (6° S. L.) there are eight rainless months; in Natal (25°–30° S. L.) seven. The central depressed regions exhibit similar phenomena. At Gondokoro (5° N. L.) there are five, at Ujiji (5° S. L.) there are eight rainless months. On the contrary, in the Usagara Mountains (6° S. L.), which are west of Zanzibar, and in the elevated equatorial region about the Victoria Nyanza, rain falls every month of the year.*

It was long ago remarked that the negro perspires less than the white. Pruner Bey has established by actual measurement that both

* Grisebach, "Vegetation der Erde."

his dermis and epidermis are thicker. I believe that these facts supply the explanation of the extreme unhealthiness of the African climate for the white man. His thin outer skin permits his system to be weakened by an undue loss of its fluids in the daytime and of its heat at night, and in this condition he falls an easy prey to some disease.

There are black men in Africa, India, and Australia, because these countries all have climates with long pronounced dry seasons. Owing to the peculiar formation of the continent of America, its tropical regions are more humid, and consequently no very dark natives are found there. Of the great Papuan race, which inhabits New Guinea and many smaller islands in that part of the Pacific, some branches are black and some brown; but I have not been able to procure meteorological data bearing on their case.

The climate and complexions of the rainless coast of Peru correspond very closely to those of the rainless valley of Egypt, the Peruvians being perhaps a shade darker. The dry climate of the tropical part of the Andes has even affected the color of the Spanish creoles; while in Cartagena and Guayaquil, towns with a humid climate on the seacoast of South America, their complexion is as light as that of native Spaniards, and fair hair still occurs, in Santa Fé, which is in the mountain country, only dark complexions with dark hair are found. Tschudi, indeed, asserts that the colder the climate (i. e., the greater the elevation), the darker the color in Peru.

Some of the evidence tending to show the connection of humidity and fairness in Africa is quite striking. In the mountainous region of Gambaragara, near the Albert Nyanza there lives, according to Stanley, a race whose fairness so struck him that he supposes that it must have come from the north. According to Lefebvre, the skin of the Abyssinians becomes lighter during the rainy season. The Bongo, Niam-Niam, and Monbuttoo tribes, whose fairness amazed Schweinfurth, inhabit a wooded and presumably a humid country, while the black Shillooks, with whom he contrasts them, dwell in a country adapted to pastoral purposes, and therefore probably dry. In the rainy regions of the Atlas Mountains there are said to be tribes among whom many individuals with blue eyes, fair skin, and red beard occur.

Similar phenomena recur in Asia. The blonde races of the Caucasus are found on its moist southern slope. The races on the dry northern declivity have a Tartar complexion. The moistest part of India is the jungle-covered southern slope of the Himalaya Mountains, and in this quarter, accordingly, we hear of white races. The Rohillas, an Aryan people, living northeast of Delhi, and the Lepchas, a Mongolian tribe, near Darjeeling, may be mentioned as examples. In the north of China proper there is a low-lying, swampy, and presumably somewhat moist peninsula called Shantung. There is some evidence tending to show that the natives of this peninsula are fairer than the rest of the Chinese.*

If this theory be correct, it is the destiny of the white race in North America to approximate in color to the aborigines. Two causes at present, to a considerable extent, counteract the effects of climate. The first is the constant influx of immigrants from the Old World ; the second, the fact that, until the great West is filled up, the struggle for existence can not become very severe, and the degree of cutaneous adaptation to climate can not assume great importance. But there are, nevertheless, indications that climatic influences are producing their natural effect. The unmixed descendants of the original settlers everywhere appear to have dark hair and a more or less sallow complexion. The writer can testify from personal observation that this is generally the case with the descendants of the united empire loyalists who settled after the Revolution in what is now the Province of Ontario. He can also testify to the darkness of the French Canadians, who derive their origin principally from Normandy, and therefore may be assumed to have at first included a large number of fair-complexioned individuals. It is remarkable that among this race a great many persons are to be seen whose features are more or less Indian in type. This, however, may (as Dr. Wilson, of University College, Toronto, supposes) be the result of an admixture of native blood.

However similar, physically, our descendants may, under the influence of climate, become to the Indians, it by no means follows that they will resemble them mentally or morally. The same struggle for existence that will eliminate the individuals ill adapted to the physical climate will also eliminate those ill adapted to the intellectual and spiritual climate, so that I am inclined to predict that the result will show, what history has indeed already established, that capacity for progress is not indissolubly connected with any particular hue.

It is obvious that on this hypothesis agreement in color does not prove, and disagreement does not disprove, community of origin. Guided by linguistic affinities, ethnologists have already in many cases disregarded color in their classifications. In the Indo-European family they include both the fair Teutons and the dark Hindoos. The white Finns and Magyars are classed with the yellow Ural-Altaic races. Black Arabs and white Jews go together in the Semitic group. But the principle has not been applied throughout. The Basques and the Caucasians, between whose languages and those of the Aryan family no relationship has ever been established, are generally considered to be nearer in blood to us than those members of the Ural-Altaic group who exemplify in the fullest degree the Indo-European type of *physique*. Hitherto the ethnological results of investigations into the physical characteristics of different races have been mainly negative ;

* See a paper by J. Lamprey, in the "Transactions of the Ethnological Society" for 1867.

the principal valuable positive conclusions have been derived from linguistic researches. In the dispute as to the relative merits of the zoölogical and philological methods in ethnology, I accordingly side with the advocates of the latter; and, in regard to the special subject of this paper, I say with Quatrefages, in the words of Virgil, "*Ne crede colori.*"

THE CARBON BUTTON.*

By E. A. ENGLER, A. M.

ALTHOUGH the telephone seems to have sprung up among us very suddenly, there have been steps in its development which show that the difficulties encountered in devising a means for the transmission of articulate speech have not been overcome altogether by a single stroke of individual genius, but singly by the patient and, for the most part, unrewarded labor of many. Each stage of its development was the outgrowth of suggestions obtained from previous experiments. Of the instruments which served their purpose in the discovery of the properties of the carbon button, a brief description will be given in this paper.

Sound is known to be produced by vibrations, generally of air; differences between sounds are due to differences in vibration. There are but three essential characteristics to be noted, all dependent upon the vibrations of the air: 1. The pitch, by virtue of which a sound is called high or low, and which depends upon the number or rapidity of the vibrations; 2. The intensity or loudness, which is determined by the amplitude of the vibration; 3. The quality by which we distinguish the corresponding tones of different instruments, and which depends on the form of the vibration. In order to obtain an exact reproduction of any sound, its pitch, intensity, and quality must be exactly reproduced; and, to render this possible, the rapidity, amplitude, and form of the vibration must be exactly reproduced.

For producing sound at a distant place two methods suggest themselves: 1. Actually to transmit the sound vibrations through the air; this is the method employed in the speaking tube. 2. To reproduce the sound vibrations at the distant station; this is the method employed in the telephone. The previous development of the telegraph naturally suggested electricity as the agent to carry the vibrations from one place to another. It thus became necessary to convert sound waves into electric waves and *vice versa*, and experiments look-

* This paper, at first intended for a special occasion, has been published at the suggestion of several friends. In its preparation, use has been made of information to be found in George B. Prescott's work on the telephone, and in the journals of science. Most of the illustrations are from Prescott's work.

ing to the accomplishment of that end were begun nearly twenty years ago.

The first successful experiments were made by Philip Reis, of Fredericksdorf, Germany, in 1861. He argued that if it could be found practicable to convert sound pulsations into electric pulsations, and then convert these pulsations back again into sound pulsations, the same effect would be produced as if the vibrations had been actually transmitted through the air. In his instruments a membrane rigidly secured on the sides was caused to vibrate in the center by the motion of the air produced by any sound. In the center of this membrane was a delicate circuit-breaker so arranged as to break the circuit of an electric telegraph line at every vibration, thus successively magnetizing and demagnetizing an electro-magnet at the receiving station, and causing its armature to vibrate in accordance with the vibrations of the membrane at the transmitting station. The vibrations of this armature, properly mounted on a sounding-board, set into vibration the surrounding air, which carried the sound to the ear. His first instrument is represented in Fig. 1. A is the transmitting and B the receiving instrument, supposed to be placed at different stations and connected with each other by a metallic conductor. A conical tube, *a b*, six inches long, four inches in diameter at the larger, and one and a half inch in diameter at the smaller end, is closed at *b* by a collodion membrane *o*, against the center of which rests one end, *c*, of the lever *c d*. This lever has electric connection with the wire of the line joining the two stations at its point of support, *e*. The end *d* of the lever rests against the flat spring *g*, which can be properly adjusted by means of the screw *h*, and which, through the metal standard *f*, is connected with the battery C. At station B the conducting wire passed around the electro-magnet *m*, which is mounted on a sounding-box W; thence to the ground. Attached to the armature at the pole of the magnet is a thin plate *i*, which is hung on an horizontal axis projecting from the upright *k*; the motion of the plate can be regulated by the screw *l* and the spring *s*. The best dimensions and most suitable adjustments of the instrument were determined by experiment. Its operation is as follows: When at rest the small spring *n* keeps the lever *c d* in contact at *g*, the circuit is closed, and the magnet *m* attracts the armature *i*. But, when by speaking into the tube *a b*, the air in the tube and therefore the membrane *o* is set into vibration, the contact at *g* is alternately broken and closed, and consequently the magnet at B is demagnetized and magnetized, alternately releasing and attracting the armature *i*. It is evident that the vibrations of *i* correspond in number and interval to the vibrations of the membrane *o*; so that the sound which enters the tube *a b* is reproduced at B so far as its pitch is concerned. But as the strength of the current is constant, neither the intensity nor the quality of the sound is reproduced.

In 1874 Elisha Gray, of Chicago, accomplished the reproduction of intensity and quality as well as pitch of sound by means of an instrument in which the strength of the current could be varied in exact accordance with the tone to be transmitted, and was thus enabled to

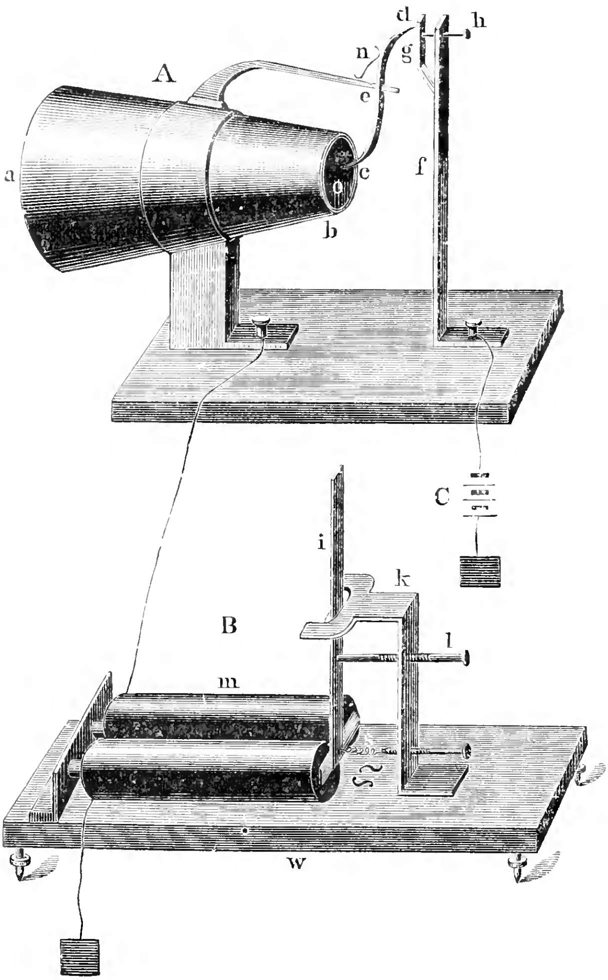


Fig. 1.

reproduce any number of tones simultaneously without losing their specific character—a thing plainly impossible with the Reis instrument. The device used is shown in Fig. 2. T_1 is a mouthpiece into which the person transmitting sounds speaks. D_1 is a tense thin diaphragm connected with the line joining the two stations. To the center of the diaphragm is fastened one end of a metal rod N, whose other end dips into a jar J containing acidulated water. A metal plug

p at the bottom of this jar is connected with one wire of the battery E, the other going to the ground. At the receiving station the wire simply passes over an electro-magnet H, thence to the ground. Close to H is placed the diaphragm D, properly provided at its center with a metal plate which serves as armature for the electro-magnet, and fastened at its circumference in the holder T. The action of the in-

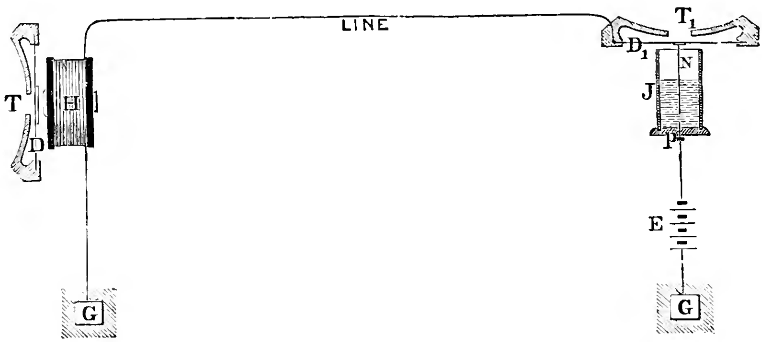


FIG. 2.

strument is as follows: The person sending the message speaks into the mouthpiece T_1, thus causing the diaphragm D_1, with the plunger N, to vibrate. The greater the amplitude of vibration the deeper the rod N descends into the liquid, and therefore the thinner the stratum of liquid through which the current will have to pass; thus the resistance to the passage of the current is varied inversely as the intensity of the sound. At the receiving station the current magnetizes the electro-magnet H, and thus reproduces in the diaphragm D the vibrations of the diaphragm D_1.

A number of telephones have since been invented, differing from each other in method of application and details of construction, but all embodying the scientific principle used by Gray.

Using the instrument invented by Reis, and the suggestions which Gray's experiments afforded, Thomas A. Edison began his attempts to construct a new form of telephone. Inasmuch as his experiments in this direction "cover many thousand pages of manuscript," only a few of the more characteristic ones will be given.

In the Reis transmitter a platinum screw was made to face the diaphragm, and a drop of water was put between them. The only result, however, was the decomposition of the water and the deposit of a sediment on the platinum. Two disks of platinum, one on the diaphragm and the other on the screw, so placed as to hold several drops of water by capillary attraction, were then tried. Acidulated solutions were substituted for water; paper and other materials, saturated with various solutions, were tried; sharp edges were substituted for disks. The result of all these experiments was complete failure, on account of the decomposition of the fluids. These were therefore abandoned and the attempt was made to vary the strength of the current by the use of platinum points, springs, and other devices. The number of these points which was to be brought into the electric circuit was to be dependent upon the amplitude of the vibration, and thus the resistance of the circuit was to be varied inversely as the intensity of the sound producing the vibration. All of these contrivances were of no avail. Subsequently plumbago and white Arkansas oil-stone were tried on account of their great resistance, and with these fair success was attained. Various expedients were used to make the portion of the material employed in the circuit proportional to the amplitude of vibration, but the confusion introduced by the devices themselves rendered the apparatus practically useless. All these experiments were conducted before the close of the year 1876.

In January of the next year the idea occurred to Mr. Edison to make use of the fact that semi-conductors vary their resistance with the pressure to which they are subjected—a thing which he had accidentally discovered while constructing some apparatus for artificial cables about four years before. He immediately set to work to construct an instrument. A diaphragm carrying at its center a spring faced with platinum was placed opposite to a small cup containing the semi-conductor to be tried. The adjustment was secured by means of a screw fastened to the cup. The vibrations of the diaphragm produced by the tones of the voice determined the pressure of the spring upon the semi-conductor. The materials first experimented upon were crude plumbago mixed with dry powders of different kinds. The results obtained were encouraging, the volume of sound being great, but the articulation so poor that some practice was necessary before the peculiar sound of the instrument could be caught with ease. An improvement was effected when, after much experimenting, solid materials were abandoned and tufts of gloss silk coated with semi-conductors were substituted. But, with all the improvement that could be devised, the instrument was still very inferior to the magneto-telephone of Professor Bell, and required such frequent adjustment as to make it very objectionable. Experiment developed the fact that the change in resistance in the semi-conductor, due to the impact of sound-vibrations, was very small, and, in order to make this change of resistance as important a factor as possible, Mr. Edison determined to make the resistance of his circuit very small: to that end he tried the primary circuit of an induction-coil, but the experiment failed. The cause of failure was at first only a matter of conjecture; but, by trying one thing after another as they suggested themselves, without any very definite purpose, conjecture finally condensed into the belief that the resistance of the semi-conductor was too great to be used with the primary circuit of an induction-coil. The effort then was to reduce the resistance of the semi-conductor to a few ohms and still be able to vary its resistance by the pressure caused by the vibrations of the diaphragm. To effect this a small circular piece, technically termed "button," of the semi-conductor was placed between two platinum disks in a small cup. Electric connection between the disks and the button was secured by inserting a small piece of rubber tubing. The first button was made of solid plumbago, and the results were quite excellent; but still the instrument was inferior to the Bell telephone. Experiments were then made upon many materials in order to obtain a button whose resistance, though small, could be greatly varied; and, when the list of substances, natural and artificial, had been wellnigh exhausted, without very satisfactory result, a fortunate accident led to the solution of the difficulty. A small quantity of lampblack had been taken from the chimney of a smoking petroleum-lamp and preserved as a curiosity on account of its intensely black color. This substance was now tried as, it would seem, a *dernier ressort.* The results were excellent beyond all hope, the articulation very distinct, and the volume several times as great as could be obtained with a magneto-telephone. It was found that the resistance could be varied by pressure alone from three hundred ohms to the fractional part of a single ohm. Fig. 3 shows an instrument used for the experimental deter-

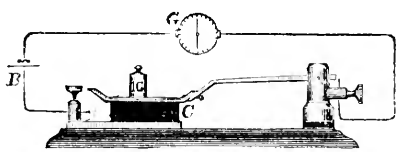


FIG. 3.

mination of the change of resistance due to pressure only. C is a piece of carbon placed between two metallic plates which are connected with the battery, B, in whose circuit is also the galvanometer G. As the current passes it must go through the carbon, the pressure on which can be varied by changing the weights placed upon it. The deflections of the galvanometer-needle indicated that the resistance of the carbon varied inversely as the pressure to which it is subjected. The best arrangement proved to be to make the resistance of the circuit $\frac{6}{10}$ of an ohm, while the normal resistance of the carbon itself was three ohms.

Good results were obtained with other materials besides carbon; the following is a list of the six most useful substances for this purpose in the order of their value: 1. Lampblack; 2. Hyperoxide of lead; 3. Iodide of copper; 4. Graphite; 5. Gas-carbon; 6. Platinum-black.

In the manufacture of the carbon button great care has to be taken that the deposit of lampblack be obtained at the lowest possible temperature, and untouched by the flame; otherwise it is utterly useless for the purpose. Thus commercial lampblack offers very great resistance to the passage of the electric current, and for that reason can not be used at all. The lampblack taken from the chimney is laid upon a white slab, where the brown portions are readily detected and removed. The pure black portion is then ground and subjected to a pressure of several thousand pounds in a mold. It is then repowdered and re-pressed several times, and finally molded into buttons weighing three hundred milligrammes each.

The special advantages of the carbon button over buttons of other materials are notably its sensitiveness to very slight changes of pressure, its remarkable elasticity and its delicacy over a long range of absolute pressures. These properties it possesses in a higher degree than any other substance, and the explanation of this peculiarity has been found in certain of its physical characteristics. Microscopic examination has shown that, of all finely divided substances, whether obtained by chemical or mechanical means, lampblack is the most finely divided. Now, it is known that the change in resistance of any piece of finely divided material, caused by change of pressure, is due to the increase or diminution of the number of particles brought into contact with each other. On this account a given change of pressure will show a greater change of resistance in carbon than in any other substance. Moreover, with other materials, a point is soon reached when additional pressure ceases to produce any appreciable change in resistance, doubtless because all the particles are already in contact. But the fact that lampblack is so finely divided enables it to respond to changes of pressure long after other materials have lost their sensitiveness. For this reason a comparatively large initial pressure can be used with the carbon, and the instrument is not so easily thrown out of adjustment. That the greater delicacy of the lampblack is due to the fact that it is so finely divided has been confirmed by experiments made with gas-retort carbon, the particles of which are comparatively coarse, graphite, which is more finely divided, and lampblack, whose particles are the finest of all. The changes of resistance for a given change of pressure were found to be proportional to the number of particles in a given volume, or inversely proportional to the size of the particles. By microscopic comparison between a Rutherford diffraction grating having 17,291 lines ruled to the inch on a piece of speculum metal, Mr. Edison estimated that there could not be less than 10,000,000 points in contact in the carbon-button when used in the telephone. This must, however, be regarded only as an approximation.

The only defect in the carbon button is its friability. But, when properly armatured, it need receive no violent shock, and will last as long as necessary. Even if it should happen to become cracked, the volume of sound would not be materially lessened. Experiments have been made to harden the button by mixing various substances with the carbon, and then subjecting the mixtures to high temperatures.

Though all these processes tend to impair the delicacy of the button, it is still far superior to a button made of any other substance.

The first application made of the carbon button was in the telephone. The arrangement of the apparatus is shown in Fig. 4. The carbon button, E, is placed between two platinum plates, D and G, which are in the circuit of a battery, as shown by the figure. Upon the upper platinum, D, is placed an ivory plate, C. A piece of rubber

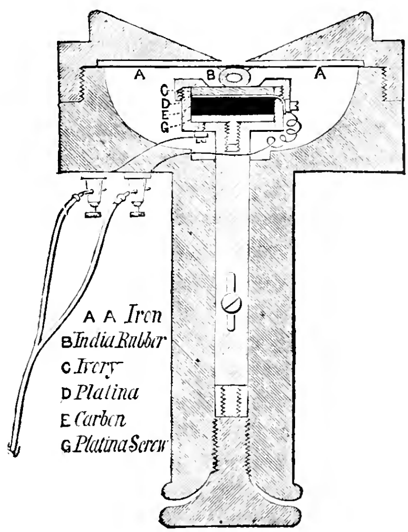


FIG. 4.

tubing, B, connects the ivory with the vibrating diaphragm, A A. All this is inclosed in a hard-rubber case with suitable mouthpiece and adjusting apparatus. The vibrations of the diaphragm communicated through the rubber cause variations in the pressure upon the carbon, and corresponding variations in the strength of the current which traverses the wire. At the receiving station an instrument similar to the one already described, invented by Gray, may be used.

At first the diaphragm was made so delicate that it continued to vibrate an appreciable time after the cause which set it in vibration ceased to act, at least long enough to cause an interference in articulation due to the mingling of successive vibrations. The object of the piece of rubber was to dampen the vibrations of the diaphragm, or to bring the diaphragm quickly to rest after it has been set in motion by a sound. The rubber was found to be somewhat tardy in its action; at best the sound emitted was muffled. The rubber had the additional disadvantage of becoming somewhat flattened with use, thus necessitating readjustment. Experiments were then made to find something which would bring the diaphragm to rest more quickly than the rubber could, and for that purpose a thin spiral metallic spring was substituted. But the spring itself gave out a tone when the diaphragm was in vibration, and was therefore objectionable. To overcome this difficulty thicker wire was used for the spring, and with better results. Trials were made with wires of different thicknesses, and it was found that the results improved as the thickness of the wire was increased, until finally the best results were obtained by using a piece of solid material rigidly secured to the diaphragm and ivory plate. It then occurred to Mr. Edison that, inasmuch as the working of his instrument depended upon changes of pressure only, there would be no need of having a vibrating diaphragm at all. A heavy diaphragm was therefore constructed and rigidly fastened to the carbon disk, so that the loudest tones would produce no vibration in it. With this arrangement the articulation was perfect, and, because the comparatively large area of the inflexible plate produced a greater pressure upon the carbon for a given tone than could be obtained when only the one point of the plate or diaphragm was used, the volume of sound was so magnified that a whisper three feet from the instrument was distinctly intelligible at the other end of the line.

Besides greater simplicity of construction, the carbon telephone possesses advantages over all others. With the telephone, as with an ordinary telegraphic instrument, there is a limit beyond which it fails to be of service, but with the telephone this limit is sooner reached than with the ordinary instruments. For this two causes are assigned: 1. The greater rapidity with which the electric impulses are sent over the line in the use of the telephone allows the line less time for charge and discharge than in Morse circuits where the transmission is done by hand; 2. The inductive action of currents passing through neighboring wires often renders the signals indistinguishable. These disturbances occur with all telephones, but they are least noticeable with the carbon telephone, because with it a stronger current is used, and therefore less sensitive receivers are required. Mr. Henry Bentley, President of the Local Telegraph Company at Philadelphia, made a set of experiments with this apparatus upon the lines of the Western Union Telegraph Company, which were on poles along with other wires through which currents were passing sufficiently strong to render the magneto-telephone useless, and found it entirely successful for a distance of from one hundred to two hundred miles. He has succeeded in using it upon a line seven hundred and twenty miles long. His experiments also show that the instrument can be used in a Morse circuit with a battery and eight or ten way-stations, using the ordinary telegraphic apparatus. It can also be used upon a wire which is at the same time being worked quadruplex.

The carbon telephone is rendered even more efficient when used in connection with the electro-motograph receiver.* For the follow-

* For a description of the motograph the reader is referred to Edwin M. Fox's article in "Scribner's Monthly," June, 1879.

ing drawing and description, given with the sanction and approval of Mr. Edison, the writer is indebted to the courtesy of Mr. S. D. Mott, of Edison's laboratory :

"The course and action of the currents in Edison's loud-speaking telephone are as follows: Reference is made to the accompanying dia-

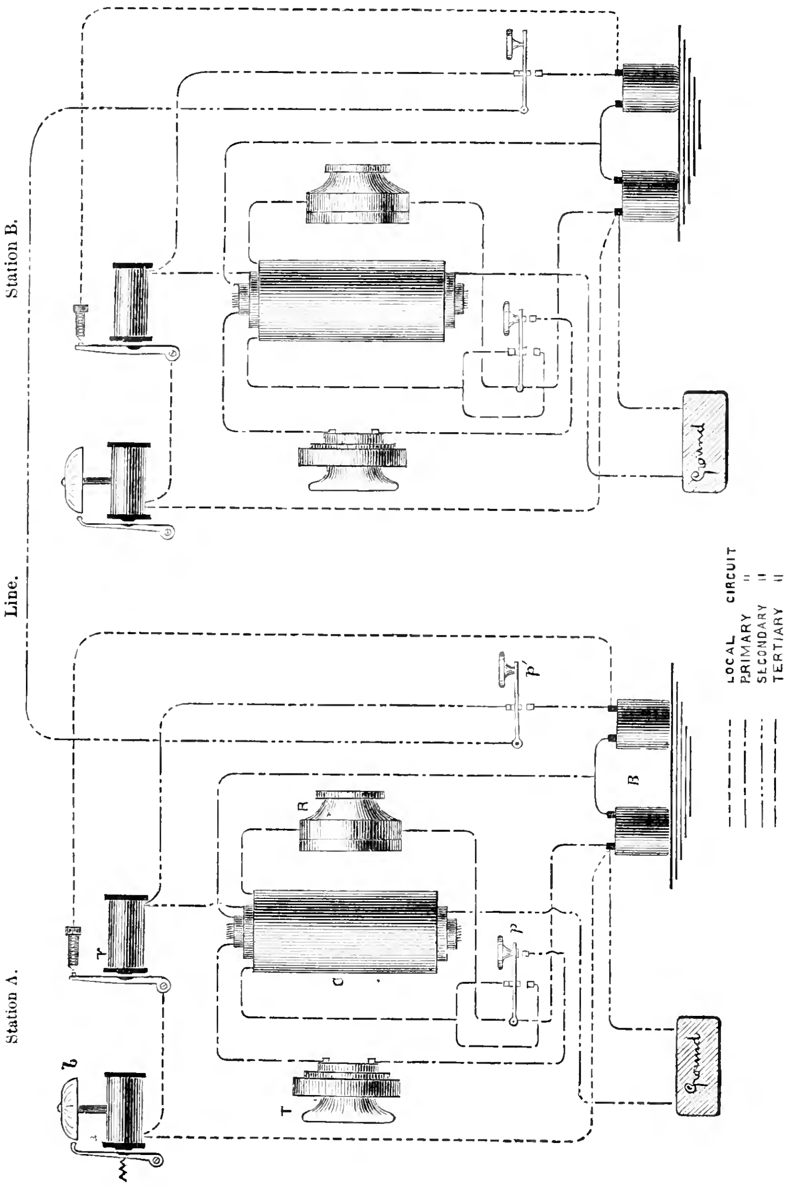


FIG. 5.

gram, Fig. 5, which represents the termini of a telephone-line; C, the induction coil, consisting of a primary, secondary, and tertiary circuit; T, the carbon transmitter; R, the electro-motograph receiver; B, battery; *r*, relay; *b*, bell; *p*, push-button; and *p'*, bell-button. The local circuit is represented in dotted lines (- - - -); the primary thus —— - —— - ——; the secondary thus —— - - - —— - - - ——; and the tertiary thus —— —— —— ——. Suppose A, station 1, wishes to communicate with B, station 2. He depresses the bell-button *p'*, when, it will be seen, a circuit is completed over the line through B's relay, closing his local circuit and ringing his bell; B then answers by depressing his bell-button and ringing A's bell. When A speaks he depresses his push-button *p* connecting his primary and tertiary, which completes his local primary circuit passing through the transmitter, where the electric impulse is transformed, as it were, into electric waves of varying number and amplitude by the peculiar property of the carbon button as varying pressure is put upon it by the vibrating diaphragm actuated by the voice. This electric wave-impulse, in passing through A's primary coil, induces a corresponding current in his secondary, which is transmitted, as may be traced over the line, into B's coil, when induction again takes place in B's tertiary, and B will then hear from his receiver what A has to say, and transmits his answer by the same *modus operandi*. The second connection that A makes when he depresses his push-button *p* is for the purpose of keeping his tertiary closed in order that B might interrupt him at any time during the communication. The reason for the alternate contact of the primary and tertiary at *p* is that each contact gives a slight but harmless knock upon the chalk cylinder of the motograph receiver, which, if occurring simultaneously, tends to disrupt its surface. For talking, one of the two Calland cells is used; for the bell the two are required. Mr. Edison has lately adopted a small electric engine instead of a crank for the motograph purposes, which occasions the use of an extra cell."

While Mr. Edison was experimenting with his telephone in order to ascertain the proper arrangement of the diaphragm, he found that the expansion or contraction of the rubber handle caused such variations of pressure on the carbon button as to render the instrument inarticulate and sometimes even inoperative. He then tried iron handles. The same trouble was experienced, and, in addition, the receiving instrument was found to emit a kind of sound, which was attributed to the molecular action of the iron during the process of expansion. The immediate result of this discovery was that the handle of the instrument was dispensed with; but it also furnished a suggestion which, calling prominent attention to the extreme delicacy of the carbon button, led to the invention of the micro-tasimeter. If the carbon button would respond to changes of pressure as small as those caused by molecular action in the handle of the telephone, it would also serve as a means of measuring such small differences of pressure, and thus furnish a comparison between the causes which produced them. The essential principle of the tasimeter is shown in Fig. 6.

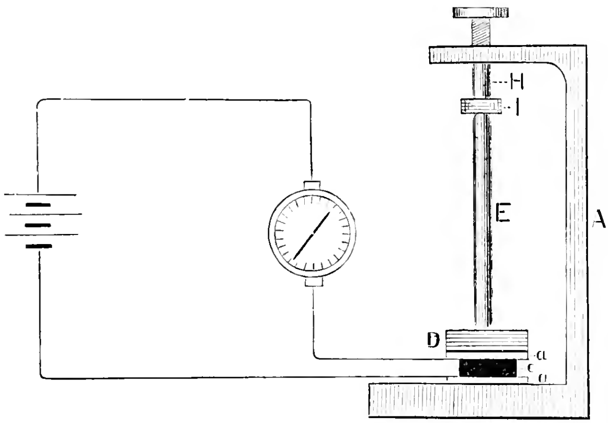


FIG. 6.

A firm standard, A, holds at its upper end a screw which works against a follower, H, to which is attached the metal cup, I. At the base, between two platinum plates, *a*, *a*, is the carbon, C; the platinum plates are in a battery circuit provided with a galvanometer. Upon the upper platinum rests a metallic cup, D. Between the two cups, I and D, is placed a piece, E, of any material upon which experiment is to be made. The expansions and contractions of E cause changes of pressure upon the carbon, and thus changes of resistance in the electric circuit which are indicated by the galvanometer. The screw-head is turned until the initial pressure is sufficient to deflect the needle a few degrees. After the needle comes to rest, the slightest change of pressure will be indicated. The delicacy of the instrument depends largely upon the coefficient of expansion of the material used at E. With a piece of hard rubber, upon which the heat from the hand placed a few inches away is allowed to act, there is a deflection in the needle of a galvanometer which is insensible to the action of a thermopile facing a red-hot iron near at hand. When extreme delicacy is required, a Thomson's reflecting galvanometer is employed in a Wheatstone bridge in the way indicated in Fig. 7. The tasimeter is placed at *i*, and adjusted to a given resistance. The resistance at *a*, *b*, *c*, is made the same. The galvanometer is placed at G, and the minutest change of resistance at *i* is indicated at the galvanometer scale.

The instrument is of service for a variety of uses. It is an excellent device for detecting and measuring small and almost inappreciable quantities of heat. In the total eclipse of the sun in 1878, by the aid of the tasimeter, what was previously only a matter of conjecture was proved to be a certainty—that the corona of the sun emits heat. The apparatus above described was arranged with as much care as possible, so that the smallest amount of heat might be detected. So great was the delicacy of the instrument that, at the time of total eclipse, when the beam from the corona was allowed to fall upon the tasimeter, the spot of light reflected from the galvanometer mirror not only changed its position, but moved completely off the scale which had been provided; so that, while the presence of heat in the corona was demonstrated, measurement of it was impossible. The instrument has also been used in measuring the heat of some of the stars.

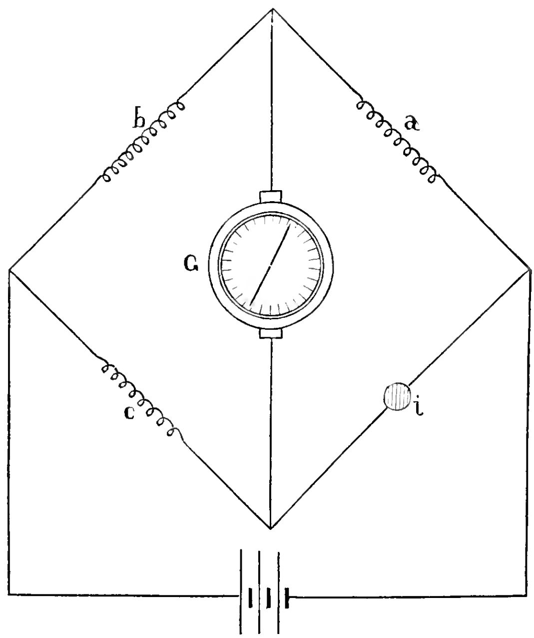


Fig. 7.

Besides being used as a delicate thermometer, the tasimeter also serves as a means of determining the coefficient of expansion of bodies; for, by having a micrometer screw attachment, the amount of expansion can be readily determined. By turning the screw, when the needle has been deflected, until it is brought back to zero, the increase in length can be read by the number of turns or parts of a turn the screw has been moved. Fig. 8 gives a section of the tasimeter, showing the micrometer screw. The piece of material to be tested is seen at A, being clamped rigidly at B, and resting in a metal socket M, which rests upon the carbon placed in the battery circuit as indicated.

The object of the funnel-shaped opening, with a small slit facing A, is to cut off all heat which is not wanted.

The tasimeter can also be used as a delicate hygrometer; by insert-

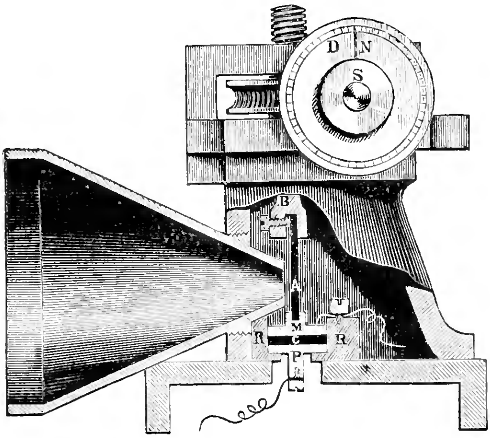


Fig. 8.

ing a piece of any substance which is capable of changing in volume as the effect of a change in moisture in the air, the pressure on the carbon will be varied accordingly and indicated by the galvanometer.

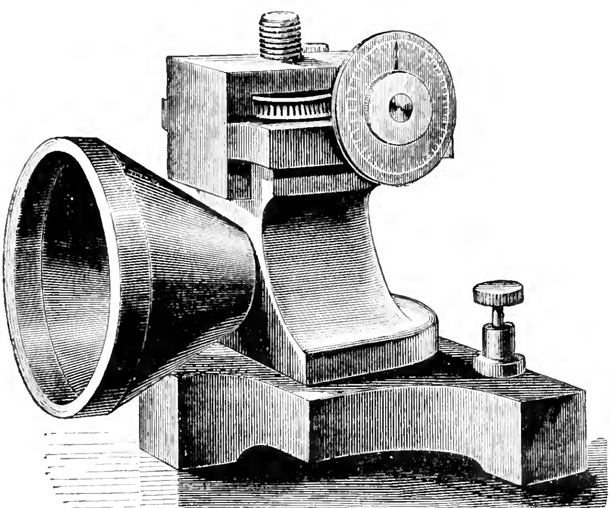


Fig. 9.—Perspective view of Micro-tasimeter.

The great sensitiveness of this instrument makes it seem probable that it will be used for many purposes not at present thought of. Special modifications for particular purposes are always possible. Fig.

10 shows a special application of the principle of the tasimeter devised at my suggestion by Professor C. A. Smith, of Washington University, St. Louis. A is a silver tube securely fastened at the top into a brass collar E. At the lower end, *o*, a steel rod, B, is firmly joined to the silver tube and runs up within it through the collar, E, and the carbon,

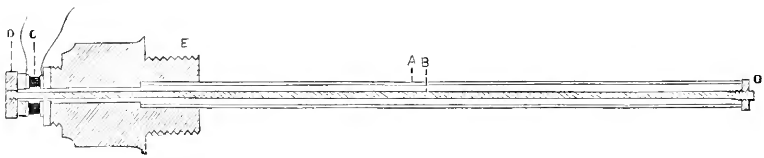


FIG. 10.

C, to a nut, D, by which the whole is clamped together. At E a screw-thread is cut, so that a brass tube, somewhat larger and longer than the silver tube, may be joined with the instrument for purposes of protection. The expansion or contraction of the silver tube, or, if the change in temperature is not sudden, the difference in expansion or contraction between the silver and the steel determines the variation of pressure on the carbon. It is proposed to use this instrument in determining the changes of temperature in steam cylinders, the laws of motion of a fluid whose temperature is not uniform, the rapidity of mixture when fluids of different temperatures are brought together, and the number of thermal units in any given volume of fluid.

After having discovered the peculiar properties of the carbon button, Mr. Edison made the current pass through several carbon disks instead of one. Increase in the intensity of the sound was noticed, but the articulation was impaired. The experiment was tried in a number of different devices, one of which is shown in Fig. 11. Instru-

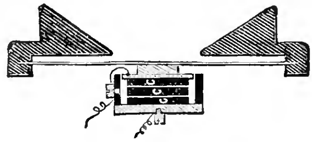


FIG. 11.

ments of this class, whose object is to magnify the sound, have come to be known as microphones, though it is doubtful if any of them succeeded in transmitting very faint sounds so that they could be intelligible at a distance.

Intimately associated with Mr. Edison's discovery and use of the properties of the carbon button are the experiments of Professor Hughes, of London. In May, 1878, Professor Hughes made the following discovery: He took a short glass tube and filled it with white silver powder, a mixture of tin and zinc. The ends of the tube were closed with plugs of gas-carbon, and the plugs secured by covering them with sealing-wax. The carbon plugs were connected with the wires of a battery in whose circuit was a galvanometer, Fig. 12. When the tube is held in the hand and subjected to a longitudinal ten-

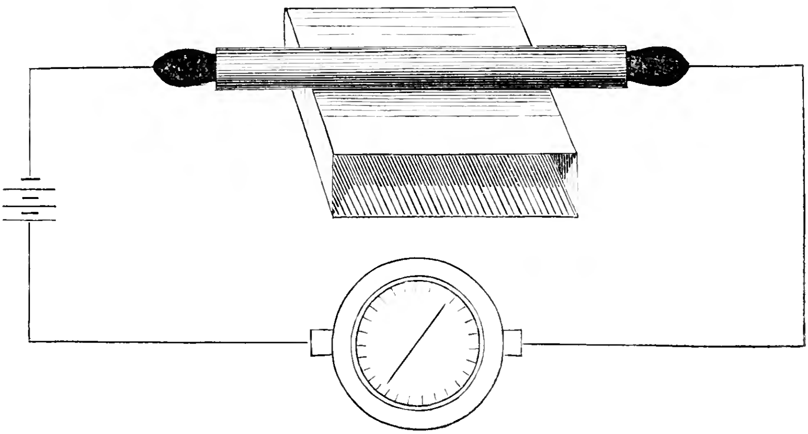


FIG. 12.

sile strain, the needle of the galvanometer is deflected in one direction; when the tensile strain is changed to a compression, the needle is deflected in the opposite direction. The explanation offered is that, when the tube is stretched, the number of particles of powder in contact with each other, and therefore the intensity of the current, is diminished; when the tube is compressed, the number of particles of powder in contact with each other, and therefore the intensity of the current, is increased. Moreover, this instrument is so sensitive that it is capable of taking up the vibrations of any sound, and of varying the electric current in accordance with them, so that the sound is reproduced at a distance in an ordinary telephone which may be placed in the circuit. If the tube is placed upon a resonating-box, the delicacy is increased. The tube in such an arrangement serves as the transmitting and the telephone as the receiving instrument. Other substances may be substituted for the white silver powder with good results. It is essential, however, that the substance used be not homogeneous. A piece of vegetable carbon plunged when incandescent into a mercury-bath, so that it becomes impregnated with particles of mercury, when placed in the tube, works quite well; pure vegetable carbon, on the contrary, is useless on account of its high resistance. Another form of transmitter is shown in Fig. 13. A piece of carbon, A, is hung on two arms, C, by a metal pivot, and rests at one end on a piece of metallized carbon, D, placed upon a piece of sealing-wax. The arrangement of the wires can be understood by the figure. Variations of pressure upon D produce variations of intensity in the current. This crude instrument is so delicate that even the tread of a fly produces a sufficient change of pressure, and consequent change of intensity in

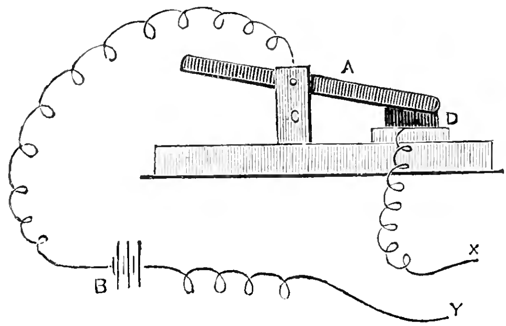


Fig. 13.

the current, to be distinctly heard in the receiving telephone. Fig. 14 shows another form of transmitter. Two pieces of gas-carbon, C C, are stuck to a pine board with sealing-wax, and connected with the wires of a battery. A third piece of carbon, A, pointed at the ends, rests loosely between them. This instrument will transmit low sounds

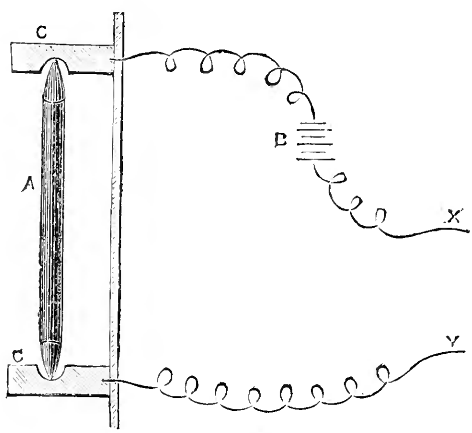


Fig. 14.

uttered at a distance from it of several yards. The capacity of the two instruments last described for transmitting sounds seems to depend upon the fact that the current is made to pass through an imperfect contact, which, when acted upon by the vibrations of sound, gives to the current an undulatory character. Successful experiments have been made with loose-jointed machinery used as a transmitter. Even a common nail laid loosely across two other nails, insulated from each other but connected with a battery, will make a good transmitter.

That the full outcome of these discoveries has not yet been reached there can be no doubt. Speculation in such matters is easy; but facts developed are sufficiently wonderful to command deepest admiration, without conjecture as to future possibilities.

GOD AND NATURE.

By the Right Rev. the LORD BISHOP OF CARLISLE.

AN elderly clergyman, dying some years ago in the east of London, bequeathed his silver spoons and the like to his nephews and nieces. But the spoons could nowhere be found. Ultimately they were discovered in a closet beneath a pile of sermons; the good clergyman having, for the sake of safety, chosen for his little stock of plate the place in which, as he imagined, it was most likely to be permitted to remain undisturbed.

I fear that I committed a mistake not long since by doing something analogous to that which was done by him whose providence I have just now chronicled, though with a different intention. I printed, in the form of an Appendix to a volume of "Oxford and Cambridge Sermons," a note on "Matter," for some portion of which, at least, I should like to crave more consideration than perhaps it has already received. The following paragraph contains the thought which I wish just now to put before the reader and to develop in this essay:

"I have referred to Cudworth's discussion of theories of matter with regard to the possible atheistic tendencies of some of them; and the time has not gone by, perhaps it never will, when the fear of atheism, as growing out of physical theories, will have ceased to exist. I am by no means prepared to say that there is no ground for such fear; but I think that some portion at least of the danger of science being found to have atheistic tendencies would be got rid of, if a clearer view could be obtained of the manner in which it is possible to establish a connection between physical theories and atheistic conclusions. It seems to me that we want a new word to express the fact that all physical science, properly so called, is compelled by its very nature to take no account of the being of God: as soon as it does this, it trenches upon theology, and ceases to be physical science. If I might coin a word, I should say that science was *atheous*, and therefore could not be *atheistic;* that is to say, its investigations and reasonings are by agreement conversant simply with observed facts and conclusions drawn from them, and in this sense it is *atheous*, or without recognition of God. And, because it is so, it does not in any way trench upon *theism* or *theology*, and can not be *atheistic*, or in the condition of denying the being of God. Take the case of physical astronomy.

To the mathematician the mechanics of the heavens are in no way different from the mechanics of a clock. It is true that the clock must have had a maker; but the mathematician, who investigates any problem connected with its mechanism, has nothing to do with him as such. The spring, the wheels, the escapement, and the rest of the works are all in their proper places somehow, and it matters nothing to the mathematician how they came there. As a mathematician the investigator of clock-motion takes no account of the existence of clockmakers; but he does not *deny* their existence; he has no hostile feeling toward them; he may be on the very best of terms with many of them; it may be at the request of one of them who has invented some new movement that he has undertaken his investigations. Precisely in the same way the man who investigates the mechanics of the heavens finds a complicated system of motion, a number of bodies mutually attracting each other and moving according to certain assumed laws. In working out the results of his assumed laws, the mathematician has no reason to consider how the bodies came to be as they are; that they are as they are is not only enough for him, but it would be utterly beyond his province to inquire how they came so to be. Therefore, *so far as his investigations are concerned,* there is no God; or, to use the word above suggested, his investigations are *atheous.* But they are not *atheistic;* and he may carry on his work, not merely without fearing the Psalmist's condemnation of the fool, but with the full persuasion that the results of his labors will tend to the honor and glory of God." *

The thought contained in this paragraph, and which may be said to be compressed in the word *atheous,* appears to me to be interesting intellectually, and valuable morally. It is not desirable that the reproach of atheism should be thrown about rashly. That there is such a thing as atheism, and that the atheistic condition of mind may be not only a very miserable, but also a very immoral one, I would not venture to deny; but that charges of atheism are not unfrequently rashly made, and the attitude taken up by scientific investigators is sometimes regarded as atheistic when it is not fairly to be described by that terrible epithet, is also true. Physical science is not more essentially atheistic than arithmetical or geometrical: all three are atheous, not one is atheistic.

Yet God and nature are very close the one to the other: the *natura naturans* and the *natura naturata* must necessarily be contiguous. We need a "scientific frontier" between them, a line which shall on no condition be transgressed by those who occupy the territory on one side or the other.

The necessity of keeping this frontier line sacred is perhaps not sufficiently recognized, and there is a great tendency to transgress it; but it is not a mere arbitrary line to be laid down by treaty, as the

* "Oxford and Cambridge Sermons," p. 280. (George Bell & Sons.)

boundaries of adjacent states are settled, but is like one of the great watersheds of nature, which no human arrangement can alter: it is like the "great divide" in the Rocky Mountains, one side of which means for every drop of rain that falls a passage to the Pacific, and the other side means a passage to the Atlantic. On a smaller scale there are similar edges on Snowdon and Helvellyn; you may stand upon them and throw two pebbles with the right hand and with the left, which will be miles apart before they come to rest.

For, in truth, the difference between the two territories, separated by our supposed scientific boundary, is greater than that which is expressed by the terms *natura naturans* and *natura naturata*.* The conception of a *natura naturans* might be merely that of a first cause, a logical beginning of nature, without any of those moral attributes which men with almost one consent associate with the name and conception of God. If the transgression of the legitimate boundaries of the field of physical science merely introduced the inquirer to metaphysical speculations, no harm would ensue, though possibly not much advantage. The condition and quality of mind which make a man a successful investigator of nature, either by the way of observation or by that of mathematical analysis, are seldom associated with those mental powers which enable a man to get beneath the surface of phenomena and speculate with any success as to the ground and underlying conditions of things. I do not say that a mind may not possess both kinds of power, but the combination is rare. Still, a man at the worst can only fail, and a brilliant observer or analyst may prove himself to be a poor philosopher, and that is the worst result that can come. But this is not in reality the result of crossing the scientific frontier. If on the one side is God and on the other nature, this means that on the one side you have a moral and religious region, and on the other a purely physical region; and the passage from one to the other is quite certain to be fraught with danger, not to say mischief.

Let me illustrate my meaning by reference to a passage in Ernst Haeckel's "History of Creation."

"Creation," he writes, "as the *coming into existence of matter*, does not concern us here at all. This process, if indeed it ever took place, is completely beyond human comprehension, and can therefore never become the subject of scientific inquiry. Natural science teaches

* I have used this phraseology as expressing the difference between the *cause* and the *phenomena* of the material universe. Bacon writes, in the first aphorism of the second book of the "Novum Organum": "Datæ naturæ Formam, sive differentiam veram, sive naturam naturantem . . . invenire, opus et intentio est humanæ Scientiæ." But upon this Mr. Ellis remarks in a note: "This is the only passage in which I have met with the phrase *natura naturans* used as it is here. With the later schoolmen, as with Spinoza, it denotes God considered as the *causa immanens* of the universe, and therefore, according to the latter, not hypostatically distinct from it." As employed by me, the phrase is not intended (I need hardly say) to have any pantheistic tendency.

that matter is eternal and imperishable, for experience has never shown us that even the smallest particle of matter has come into existence or passed away. . . . Hence a naturalist can no more imagine the coming into existence of matter than he can imagine its disappearance, and he therefore looks upon the existing quantity of matter in the universe as a given fact. If any person feels the necessity of conceiving the coming into existence of this matter as the work of a supernatural creative power, of the creative force of something outside of matter, we have nothing to say against it. But we must remark that thereby not even the smallest advantage is gained for the scientific knowledge of nature. Such a conception of immaterial force, which at the first creates matter, is an article of faith which has nothing whatever to do with human science. *Where faith commences science ends.* Both these arts of the human mind must be strictly kept apart from each other. Faith has its origin in the poetic imagination; knowledge, on the other hand, originates in the reasoning intelligence of man. Science has to pluck the blessed fruits from the tree of knowledge, unconcerned whether these conquests trench upon the poetical imaginings of faith or not."*

With much which is contained in the preceding quotation I entirely agree. *Where faith commences, science ends;* this is perfectly true; but I miss any recognition of the truth that the supernatural power which most persons "feel the necessity of conceiving" is something much beyond a "creative force outside of matter." It is difficult, I think, for most of us to keep our minds clear of the conception of such force outside of matter, though I quite agree with the author that nothing is gained for the scientific knowledge of nature by adopting the conception. But what I think the mind feels chiefly the necessity of conceiving is the existence of a Being who is the ground of all the *moral* phenomena of the world; and, if a writer on natural history goes beyond his subject at all, he should recognize the fact that the passing of the boundary carries the mind into a region of moral philosophy and religion, and not merely into a speculation concerning the possible origination of matter.

That this criticism is not unfair and not unimportant may be, I think, concluded from the results to which Ernst Haeckel is himself led, and to which he wishes to lead his readers. He tells us that he has no fault to find with the hypothesis, if we feel it to be necessary, of an origin of matter; but he tells us subsequently that there is no purpose in nature, and no such thing as beneficence on the part of a Creator.

"Every one," he writes, "who makes a really close study of the organization and mode of life of the various animals and plants, and becomes familiar with the reciprocity or interaction of the phenomena of life, and the so-called 'economy of nature,' must necessarily come

* Vol. i., p. 8 (English translation).

to the conclusion that this 'purposiveness' no more exists than the much-talked-of 'beneficence' of the Creator. These optimistic views have, unfortunately, as little real foundation as the favorite phrase, 'moral order of the universe,' which is illustrated in an ironical way by the history of all nations. The dominion of 'moral' popes, and their pious Inquisition, in the mediæval times, is not less significant of this than the present prevailing militarism, with its 'moral' apparatus of needle-guns and other refined instruments of murder." *

This passage, as will be seen, takes us into the region of morals. There is no question here of permitting the hypothesis of an originating force outside of matter, if we feel such an hypothesis intellectually necessary; but we have instead a denial *ex cathedra* of the existence of such a thing as a moral order or of such a person as a beneficent Creator. This is not merely *atheous;* it is *atheistic.* An investigator of nature has a right to say that the question of the existence of a beneficent Creator or the non-existence of such a Being does not affect his investigations; but he has no right, upon the strength of investigations purely physical, to deny the existence of beneficence as an attribute of the Creator, if a Creator there be.

But I am not surprised to find utterance given to some expression of opinion as to the moral character of the Creator, when once the legitimate boundary of physical science has been transgressed. If a man can be satisfied with examining nature as he finds it, whether as an observer or as a mathematician, the question of a Creator need no more trouble him than it troubles the man who is busied with integrating equations or devising a new calculus; but if he is not satisfied with this, then he can scarcely stop short of a complete investigation of the whole question of theism; and the elements necessary to this complete investigation are certainly not to be found in physics, any more than you can find in physics the material for a complete treatise on poetry or music or painting.

For, in truth, physical science does not afford the basis even for a complete investigation of ourselves. When *anthropology* is classed among the physical sciences, it is necessary to confine the investigations comprehended under the title to the consideration of man as a creature having certain material attributes and leaving certain material marks of his existence in past ages: a study of the highest interest, and one which students have a right to call *anthropology*, if they please: but manifestly anthropology can not be translated by the words "the science of man," for the science of necessity leaves out of consideration all that is most interesting to man or which makes man most interesting.

To say that physical science does not include the study of man is perhaps nearly the same thing as saying that man is not a part of nature; and though such an assertion may seem paradoxical, there is

* Vol. i., p. 19.

a sense in which it is quite true, and it is important to observe what that sense is. Putting aside all questions of immortality, it is not difficult to conclude that mankind possess attributes which do not belong to other creatures, and which make it necessary, in examining the world, to put man in a class by himself.

Take a few examples. Let the first be that of will. The question is whether a human being has a command of his actions in a manner in which no other creature has. Simple experience seems to me to prove that he has: I do not feel that I need the help of philosophers to solve the question. A dog or a horse has in a certain sense a will, but I can calculate how a dog or a horse will act, if I know the conditions to which it is subjected; whereas I positively know from actual experience that I can do as I choose, independently of all external influences. Bring me to the test: tell me in any given circumstances what those circumstances will lead me to do, and I will undertake to do something different. And the power of will implies the capacity for self-sacrifice. Every animal is by its very nature selfish. Doubtless there are, in this as in other things, faint reflections of humanity in the humbler creatures, just as the *στοργή* of the animal, which lasts for a short time and utterly dies out when it has served its purpose, is the faint reflection of that human love which lasts through life and grows with years; but there is nothing in the life of animals which can be seriously named as being of the same kind as that feeling which inspired a Howard, or a Wilberforce, or a St. Vincent de Paul. The man who deliberately puts aside that which is most pleasant to men in general, and which he himself has every capacity to enjoy, and does something quite different from the dictates of his nature because he judges that something to be right or good, exhibits a quality and a power which is simply lacking in every other living creature except the human race.

Again, regard man as a being of purpose. I quoted a passage not long ago from Ernst Haeckel, in which he denies the existence of purpose in nature. Can purpose be denied to exist in man? If I am not mistaken, the whole history of civilization may be described as a development of purpose. Every other creature is apparently content with the condition in which it finds itself. Birds build nests as their ancestors did thousands of years ago; fishes have no ambition; possibly the time may have been when ants did not know the luxury of keeping aphis-cows, or being waited upon by slaves of their own race; but, speaking generally, it may be said that unprogressiveness marks all other animals, as distinctly as progressiveness does man. I put out of consideration, as not belonging to the argument, the question of evolution, and the progression of living things in that sense of the word. I am speaking only of nature as we see it now, and not as it may possibly once have been; and certainly, as things are now, it seems impossible to deny that while the animals about us are as fixed in their habits and instincts as the plants, or nearly so, there is one race, namely, the human, which is not fixed at all, but is constantly devising something new, regarding nothing as gained while anything remains to be achieved.

Once more, take the more general attribute of thought. Much has been written of late concerning the minds of animals; it is a curious and interesting subject, and certainly I for one do not grudge our humbler friends in the great world-family of life any gift of mind with which they have been endowed. The brain of the ant is, as some one has truly said, perhaps the most wonderful little morsel of matter in existence. But certainly the mind of man is so incomparably more powerful and effective a machine of thought, that any comparison between it and the mind of the most gifted animal appears almost ridiculous. The fact is that our natural tendency is so much to assume the utter non-existence of mind in animals, that, when we find evidence of mind which we can not resist, we stand amazed at the discovery. In many things, as we know, the inferior creatures are much more clever than ourselves; we could never build a nest like a bird, or make a comb like a bee, or do ten thousand things which are being done every day by spiders and beetles. But still thought in the highest sense belongs to man. A dog sometimes looks as though he was thinking a thing out, and dog-stories are very wonderful; but, after all, the cleverest dog that ever lived yet has never been able to get beyond "Bow-wow," and we may safely predict that no dog will ever acquire even the simplest elements of human knowledge. I can not believe that this power of thought can properly be described as the mere result of phosphorus in the brain. That epigram, "*No phosphorus, no thought*," strikes me as having in it more of smartness than of wisdom. It is of course true that the brain is in some manner the organ of thought, and phosphorus may be the most important element in the formation of the brain; but is not thought conceivable independently of this particular machinery for making it possible to a material creature, just as motion is conceivable apart from horses or steam, or any of the causes to which it is commonly due? Is there not a kind of absurdity in regarding thought as the result of phosphorus, as real as if we should say, what upon the same principle of philosophy we might say, that truthfulness, kindness, modesty, were all functions of phosphorus? Nay, I do not know why we should not go further, and assert that there could be no thought without carbon or without any other element of which the human body is composed; for you can have no actual thought without a living creature, and no living creature without a body, and no body without carbon, ∴ etc.—Q. E. D.*

* I had not observed, when this was written, that the Archbishop of York had said nearly the same thing. "Without time, no thought; without oxygen, no thought; without water, no thought. All these are true, and they import a well-known fact, that man who thinks is a creature in a material world, and that certain forms of matter are need-

All these examples lead up to one sovereign attribute which comprehends and implies both them and others equally important, namely, the attribute of personality. A man can say, with a full sense of the meaning of what he says, not merely "I eat, drink, and sleep," nor even "I am conscious of will, purpose, and thought," but "I *am:* I am a conscious person, not a mere machine, though the proprietor of a wonderful piece of machinery. My body, my brain, my mind, are not merely things which work with a living innate power, but they are *mine*, they work for *me*, they do what *I* tell them. If they are out of order, I know it, and I complain of it; I say, for instance: 'I have overtasked my brain, I must give it some rest before I can do this or that; I know what I wish to do, and feel myself competent to do it, but my brain will not obey me because it is tired, just as my horse may be overworked, or as my knife will not cut when it has been blunted by too much use.'" So of the moral feelings. I can discuss them, I can guide my conduct by means of them, I can feel ashamed of this or that failure in upright or high conduct. A man knows that he is responsible for his actions. Sometimes a murderer is convicted twenty years after the offense has been committed, or he gives himself up after as many years because his memory and his conscience make his life intolerable. He has no doubt as to the fact that the person who did the deed of darkness years ago is the same person as he who feels the pangs of remorse to-day. Every material particle in his body may have changed since then; but there is a continuity in his spiritual being out of which he can not be argued, even if any ingenious sophist should attempt the task. No ingenuity will prevent the conscience-stricken murderer from pleading guilty.

There are, undeniably, anomalies of a very remarkable kind connected with the sense of personality, and cases are recorded in which men and women have had (as it were) a different personality at different times. An instance is recorded of a young woman who habitually passed from one state of existence or consciousness to another, so distinct that when in the second state she knew nothing of what had happened when she was in the first. For example, having returned upon one occasion from a funeral, she fell asleep, and awoke in a few moments in her second state; all remembrance of the funeral was gone, and she wondered why she was in mourning. This case appears to have been carefully and scientifically watched for many years, and to have given undeniable evidence of what may be described as a double existence or double consciousness; so that the being in question would have no true sense of personality, and certainly would not be admissible in a witness-box as evidence of any event said to have taken place.* Instances more or less of the same kind may probably be

ful to his existence as an organized being."—("Design in Nature," "Word, Work, and Will," p. 244.)

* I take this from the "Causeries Scientifiques," 1877 (Rothschild, Paris).

produced without limit. What they prove is, that we are dependent for the proper use of our faculties upon material conditions; the *corpus sanum* is one condition of the *mens sana;* but they do not prove the unreality of the attribute of personality any more than the existence of idiocy and insanity, or even the possibility of getting drunk and so losing all sense of who and what we are, prove it. Undoubtedly everything depends, in the case of a human being whose powers are exerted through material organs, upon the proper working condition of those organs, and a pressure of blood upon the brain may make a man of the holiest life and the most philosophical temper commit suicide, as experience proves. But all such morbid exceptions to the general rule can not destroy the belief which a man in his normal condition feels compelled by the conditions of his existence to hold, namely, that he is himself and no one else, that he is responsible for his actions, and that what he does now will bear fruit in his subsequent experience either for good or for evil, unless he becomes deranged. The author from whom I have taken the above case of double personality exclaims very naïvely: "Ah! comme il faut avoir un peu de saine complaisance pour les sept péchés capitaux! Jugez: un peu de sang de trop, peut-être un centième de gramme mal dirigé au contact d'une pauvre petite résille de nerfs, et le voilà fait, l'orgueilleux, le vaniteux, le superbe!" True: we must be cautious in forming opinions of actions; and in any human court—we may believe also in the court divine—every circumstance connected with an action must be taken into account in order that a just judgment of it may be formed; but all this does not prove that there is no such thing as haughtiness, or vanity, or pride, or that sane men are not responsible for their temper of mind and the quality of their actions.

To come back, then, to the conception of personality. I can not but feel sure that this is the highest conception that I can possess of my own being, or of any kind of being. All history seems to transmute itself into a kind of phantasmagoria or illusive pantomime, unless the attribute of personality be conceded to the actors. Socrates, Alexander, Julius Cæsar, Cromwell, Napoleon, must be studied without reference to phosphorus, and upon principles lying altogether outside the territory of physical science. And this postulate of personality seems to me to lead, by an intellectual necessity, to the conception of personality in a region not of φωσφόρος, but of Φῶς itself, the conception of *the Person*, ὁ ὤν, of whom persons like ourselves are, as it were, a faint reflection.

The study of the being and doings of this Person would seem to be of necessity one of the most interesting that can be suggested to the mind of man. The study may be conducted upon different, though not crossing, lines; the chief lines being the physical, the metaphysical or philosophical, the moral, the religious. Each of these branches has its own method and its own sources of illumination; each also has its own peculiar difficulties and its own anomalies and contradictions. A really complete scientific theism, such a theism as Bacon would have delighted to map out in detail, would comprehend all the different departments of which I have spoken, and in the unity of such a system physicists and philosophers and divines would be able to meet and shake hands.

It is a curious subject of inquiry, and the reader will, I think, pardon me for here introducing it, how far, upon the theistic view of nature, we can discriminate between that which is necessary in the nature of things and that which is to be regarded as being such as it is in virtue of a divine purpose or choice. It seems clear, for example, that when once matter is assumed to be the subject of a divine operation, as in the case of the universe with which we are acquainted and of which we form a part, certain necessary conditions are imposed upon the creative work or upon the system of nature. These conditions may be, in a certain sense, limitations of divine power; but they are not limitations in any more objectionable sense than are the truths of geometry or number, to which all created things must be conformable. Sometimes a condition of this kind exists which is not at all obvious at first sight, and which, nevertheless, is as necessary to be taken into account as the truth that two and two make four and can not make five. Thus, for example, Laplace suggests that the utility of the moon is not as great as it might have been, and he points out an arrangement according to which, as he shows, the earth would have received much more light than it actually does; but I remember having read a memoir by Liouville in one of the numbers of his "Journal," in which he shows that the arrangement proposed by Laplace would not be *stable*—that is, that it would only be possible in the sense in which it is possible to make a pin stand upon its point. An example of this kind shows the necessity of caution in any suggestions which may be made for the improvement of natural arrangements. But it does more than this; it helps to illustrate the point which I am now endeavoring to discuss, with reference rather to the philosophy of the arrangements which we see than to any suggestions for improving them.

Let us consider for a moment what is called by mathematicians the *principle of least action*. Putting this principle into popular language, it may be described as asserting that the motion of bodies generally takes place in such a manner that the energy expended in the motion is the least possible. From this principle, when enunciated in a strict mathematical form, the equations of motion of a system may be deduced, or, in other words, the problem of the motion of a system may be solved. The remarkable fact connected with this principle is, that its truth was evolved by a speculative mind out of the general principle that nature would use the least effort possible to produce a given result, before it was demonstrated in its strict form by mathematicians; and, looking upon it thus, we should be disposed to regard the form of motion which involves least effort as being chosen out of all possible forms, much in the same way as a man who has to perform a journey or to do a certain piece of work inquires how the journey or piece of work can be reduced to a minimum of trouble or expense. But the fact of the "principle of least action" being mathematically deducible from the principles of motion would seem to prove that there is in reality no choice in the matter, but that *least action* is as necessary a truth as is that of the least distance between two points on a sphere being that which is traced by the great circle joining them.

Just consider this question of two points on a sphere. As a matter of geometry it is easy to show that the shortest path between them is that given by the great circle, and this principle is now well recognized in navigation. But change the problem from geometry to dynamics, by supposing a particle to move on the surface of a smooth sphere under the action of a force tending to the center, as that exerted by an elastic string in a state of tension; then it is equally easy to prove that this particle, when started in any direction, will describe a great circle—that is, its motion will be such that the distance traversed by it in passing from its point of departure to any point in its path will be the shortest distance between those points. It might be said that the particle *chose* the easiest path, but in reality there was no choice, nothing but necessity; in other words, the dynamical minimum stands on the same footing as the geometrical.

In truth, the question of *minimum* comes under our notice very frequently and very curiously in nature. The path of a ray of reflected light may be determined upon the principle that it is the shortest possible; and this is not the only case in which the law of minimum is illustrated by optics. But take a very different case, that of the cells made by the bee. It is well known that the bee is a wonderful geometer. The cells consist of hexagonal prisms closed at the ends with three tiles having exactly the angles which with a given amount of material will make the cells most capacious, or with a given capacity will use the smallest amount of material. This has been long known, and has given rise to much speculation as to the manner in which the bee is guided to so remarkable a result. I am not aware that any satisfactory solution has yet been proposed; but the intellectual conception of the problem is much simplified if we bear in mind that the transverse section is the nearest form possible to a circle, and the form of the end of the cell the nearest possible to a sphere; so that it may be said that the instinct of making circular prismatic cells with spherical ends, and then clearing away unnecessary wax, is all the instinct which the bee requires. Let the reader observe that this is said, not with a view to depreciate the bee's architectural skill, but only for the purpose of pointing out that the application of the wax in the most economical manner, making it go as far as possible, subject to the condition of forming prismatic cells, is a geometrical result from adopting the simplest plane and solid figures, namely, the circle and the sphere. Let me illustrate this by a single example. Suppose I gave a coppersmith a lump of copper, and said, "Make this into a bowl of given thickness, having a maximum of capacity"; my coppersmith would undoubtedly be posed. But suppose I said, "Make this into as simple a bowl as you can, and let the material be of such a thickness": he would almost certainly make it hemispherical, or nearly so, because that is the simplest form; but his hemispherical bowl would, as a matter of fact, possess the property of maximum content which I wished it to have.

It seems to me, therefore, that there may be not a few cases in which arrangements, that appear at first sight to be the result of a choice among many that might be possible, are in fact arrangements which are necessitated by geometrical conditions, or what may be equivalent to them. This consideration should make us cautious in attributing to an arbitrary will facts which might seem at first sight to warrant this conclusion. Then, again, there are phenomena in the ordinary functions of nature, having the appearance of chance, which yet are not chance in the true sense of the word, but which have strongly the appearance of it, and for which it is difficult to give any account. The manner in which plants turn toward the light is to me a profound mystery; there must be a force to produce the motion, but I do not perceive whence it can arise. And the instinct of seeking the light sometimes assumes the most wonderful form. I think I have read of a potato in a dark cellar throwing out a long sprout which extended itself till it emerged at a hole at a distance through which light entered. The power which living matter has to adapt itself to unforeseen circumstances, of which this potato may be taken as a humble instance, has very much of the appearance of choice. A limb is broken, or a skull is trepanned, and the limb becomes as strong as ever, and the skull retains whatever brain it may have had within it, in virtue of new efforts of nature exactly adapted to the wants; but these wants are such as could not have been foreseen, and could scarcely have been included in the original idea, so to speak, of the man to whom the accident has happened.

Therefore I feel that we are on very difficult and mysterious ground when discussing the place which should be assigned in nature to *choice*. I think that we ought to recognize the fact that many things in the edifice of nature, which might strike us at first sight as the arbitrary touches of the great Architect, may in reality be the results of geometrical or other necessity inherent in the conditions of space, or time, or matter. Nevertheless, it is difficult to believe that a creation such as we see round about us, and of which we form a part, could have been evolved out of its primitive elements without the exercise of that which, for want of a better word, I will call choice. Why should our hearts be on the left side rather than on the right? Why should we have five digits rather than seven? Why should we have one thumb rather than two? Why, to take a larger instance, should the planets be exactly such as they are in size and in other conditions, which apparently follow no law whatever? Why should the exact quantity of matter exist which does exist, for an infinite quantity is, I suppose, inconceivable? And what determines the precise pace at which all the bodies which constitute the universe move? To use the language of a mathematician, what determines all the arbitrary constants and arbitrary functions in the integrals of nature's equations? This string of questions might be lengthened indefinitely, but the reader will see what the force of them is. If the principle of symmetry could be asserted concerning the human body or concerning the solar system, that symmetry might answer many questions; it might be said, "This or that is so, because there is no reason why it should be otherwise." But there is an absence of symmetry from many parts of nature, and, when no geometrical or other cause can be assigned, you need the hypothesis of an independent will in order to render the irregular formation in any degree intelligible. A supreme will throws light upon the darkness; it may leave some difficulties unsolved, but we feel that in it we have got the key.

But my pen has run as far as perhaps my readers will care to follow me; and I conclude, therefore, by reminding them of the thesis which my essay has been intended to illustrate. It is the relation of God and nature, and the connection between the study of the latter and the knowledge of the former. I would say at the end what I said at the beginning, that physical science is properly and necessarily *atheous*, but not properly and not necessarily *atheistic*. Clerk Maxwell, that great intellect, whom Cambridge and the world have recently lost, was no atheist, but a devout believer in God; yet no man had penetrated more deeply and more successfully into the arcana of matter, and discussed more profoundly and more ingeniously the molecules of which the universe is made. Is this wonderful? I think not. It seems to me that, while it is the duty of a scientific inquirer, as such, to exclude from his inquiries anything that at all transcends the natural region, and therefore God can have no place in his inquiries, yet the moral effect of the discipline of investigation ought to be, in the case of a well-balanced mind, to compel it, if need be, to "cross the boundary of experimental evidence" and recognize the existence of Him "who hath created all things," in whom "we live, and move, and have our being."—*Nineteenth Century.*

THE BUFFALO AND HIS FATE.

By ERNEST INGERSOLL.

PERHAPS no indigenous animal of this country has attracted more attention or met with a greater number of biographers than the bison or buffalo. Its history has been a tale of extermination, and a very few years are likely to see the last of these noble beasts roaming over the Plains. For hundreds of years the few that remain of the herds of aurochs, the European bison, have been kept in the parks of the nobility; but, in this "free" country, not even this means of safety seems left to our persecuted buffalo.

To the Spanish colonists the American bison was commonly known under the name of *cibola*, while the French usually called it *le bœuf*, *buffle*, *vache sauvage*, or *bison d'Amérique*. Peter Kalm, who traveled through America in 1749, spoke of them as *wilde ochsen* and *kühe*. But the word *buffalo*—at first spelled *buffelo*—soon replaced the earlier names. Scientific men claim that our species (*Bison Americanus*, Smith) should be called bison, as buffalo is applicable only to the East Indian genus *Bubalus*.

It appears that our bison has already outlived at least two other races, which exceeded it in size—the *Bison latifrons* and the *Bison antiquus*. The former was contemporary with the mastodon, and was an ox of gigantic bulk, the tips of whose horns were eleven or twelve feet apart, and which probably stood as high as an elephant. Of the latter species more abundant remains have been dug up, particularly from the ice-cliffs at Escholtz Bay, on the Arctic coast north of Alaska. This fossil ox was of smaller size than the *Bison latifrons*, but much larger than the existing buffalo, although not greatly different from it in form. It seems to have been spread over the northwestern half of the continent from the Ohio Valley to Alaska, and everywhere its remains occur with those of the larger extinct mammalia, yet it may have survived to a comparatively recent date.

With the appearance of the buffalo, which only a few decades ago swarmed in prodigious herds over nearly a third of North America, all are familiar. The male measures about nine feet from the muzzle to the insertion of the tail; the female about six and a half feet. The height to the top of the hump of the male is five and a half to six feet, and of the female about five feet, sloping in each case to a height at the hips of four and a half to four feet. The weight of the old males is nearly two thousand pounds, while the cows weigh one thousand to twelve hundred pounds. The horns are short, thick at the base, curved, and sharply pointed; the hoofs are short and broad; the short tail ends in a tuft of long hairs. In winter the head and whole under parts are blackish-brown; the upper surface lighter, fading as spring advances.

Young animals are of a darker, richer brown than the old ones, age bleaching the thick masses of long, woolly hair, which falls so abundantly over the shoulders and face, to a light yellowish-brown. In the spring the hinder parts are almost naked through the molting of the hair, while that upon the shaggy fore parts remains permanently. Pied coats are occasionally met, and examination and measurements of skulls and skeletons show much individual variation in form and proportions.

In Mr. J. A. Allen's recent book * upon "The Bison, Past and Present, in this Country," which is one of the most complete and admirable monographs ever written on any subject, and from which I derive my facts, an extended account of the animal's history and habits is given.

As is well known, the buffalo is preëminently gregarious—herds numbering millions of individuals, and blackening the whole landscape, having formerly been met with constantly on the Plains. Emigrant trains used to be delayed by the passing of dense herds, and during the first years of the Kansas Pacific railway its trains were frequently stopped by the same cause. These masses seem to have some sort of organization, consisting of small bands which unite in migration or when pursued, but separate when feeding. The cows, with their calves and the younger animals, are generally toward the middle of the small herd, while the older bulls are found on the outside, and the patriarchs of the herd bring up the rear. Much romancing has been wasted on this simple and natural grouping by writers who have described the supposed regularity and almost military precision of their movements. The sluggish, partly disabled old males constitute the "lordly sentinels" of such tales, who are supposed to watch with fatherly care over the welfare of their "harems." The truth is that these protectors, fancied so alert, are the most easily approached of any of the flock, and the real guardians are the vigilant cows themselves, who usually lead the movements of the herd.

The rutting-season is July and August. The period of pregnancy is nine months, and rarely more than a single calf is born, which follows the mother for a year or more. During the rutting-season the bulls wage fierce battles, but they rarely result fatally. The short horns are not very dangerous weapons, and the masses of hair on the forehead break the force of the stunning collisions. At this season the bulls become lean, regaining their flesh in autumn, while the cows are fattest in June. During its molting in midsummer the animal possesses a very ragged and uncouth appearance, the hair hanging here and there in matted, loosened patches, with intervening naked spaces; and it endeavors to free itself from this loosened hair, by rubbing

* Volume I., Part II., "Memoirs of the Geological Survey of Kentucky," Professor N. S. Shaler, Geologist, in charge; and reprinted by the Museum of Comparative Zoölogy as one of its "Memoirs." Cambridge, 1875.

against rocks and trees, or rolling on the ground. Their coats are in prime condition for robes in December.

The buffalo is nomadic in its habits, roaming in the course of the year over vast areas in search of food or safety. The fires that annually sweep across thousands of square miles of the grassy plains, the ravages of grasshoppers, often destroying equally extensive tracts of vegetation, and the habit of keeping in compact herds, which soon exhaust the herbage of a single region, all compel constant movement. There is a popular belief that the buffaloes used to migrate from the northern plains to Texas in fall and back again in spring, but this seems erroneous. Before the intersection of the West by railroads and emigrant trails their movements were more regular, no doubt, than at present, and slight northward and southward migrations are well attested as occurring in Texas and also on the Saskatchewan plains; but the herds constantly winter as far north as the latter region, and for twenty-five years have not passed southward even to the Platte. In the extreme north they leave the exposed plains in winter and take shelter among the wooded hills. Such local movements as these were formerly very regular, and hunters knew just where to look for their game at any season of the year.

The behavior of the buffaloes is very much like that of domestic cattle, but their speed and endurance seem to be far greater. When well under way it takes a fleet horse to overtake them, and they raise a column of dust which marks their progress when miles away. They swim rivers with ease, even amid floating ice, and show a surprising agility and expertness in making their way down precipitous cliffs and banks of streams, plunging headlong where a man would pick his way with hesitation. Ordinarily, however, the buffalo exhibits commendable sagacity in his choice of routes, usually taking the easiest grades and the most direct course, so that a buffalo-trail—often worn deep into the ground—can be depended on as affording the most feasible road through the region it traverses.

When belligerent, the old bulls make the most blustering demonstrations, but are really cowardly. Facing the approaching hunter with a boastful and defiant air, they will pace to and fro, threateningly pawing the earth, only to take to their heels the next moment. The bulls greatly enjoy pawing the earth and throwing it up with their horns, digging into banks or getting down upon one knee to strike into the level surface, so that the sheaths of their horns are always badly splintered. They are very fond, too, of rubbing themselves, and evidently regard the telegraph-poles along the railroads as set there for their especial convenience in this respect. But their chief delight is in "wallowing." Finding in the low parts of the prairie a little stagnant water among the grass, or at least the surface soft and moist, an old bull plunges his horns into the ground, tearing up the earth and soon making an excavation into which the water trickles, forming for a short time a cool and comfortable bath, in which he wallows like a hog in the mire, swinging himself round and round on his side, and thus enlarging the pool until he is nearly immersed. At length he rises besmeared with a coating of mud, which, drying, insures him immunity from insect pests for many hours. Others follow, each enlarging the "wallow" until it becomes twenty feet in diameter, remains a prominent feature in the landscape, and forms a cistern where a grateful supply of water is often long retained for the thirsty denizens of that dry region.

Like the other species of the bovine group the bison is of a sluggish disposition, and mild and timid, ferocious as his shaggy head and vicious eye make him look. He rarely attacks, except in the last hopeless effort of self-defense. "Endowed with the smallest possible amount of instinct," says Colonel R. I. Dodge, "the little he has seems adapted rather for getting him into difficulties than out of them. If not alarmed at sight or smell of a foe, he will stand stupidly gazing at his companions in their death-throes until the whole herd is shot down. He will walk unconsciously into a quicksand or quagmire already choked with struggling, dying victims." Having made up his mind to go a certain way, it is almost impossible to swerve him from his purpose, and he will rush heedless into sure destruction. Two trains were "ditched" in one week on the Atchison, Topeka and Santa Fe Railroad by herds of buffaloes rushing blindly against and in front of them. Finally the conductors "got the idea," and gave the original occupants of the soil the right of way whenever they asked it. During a voyage down the upper Missouri in 1877, our steamer more than once had to stop to allow swimming herds to get out of the way, and once we completely keel-hauled a sorry old bull. Yet, as Mr. Allen suggests, their inertness may be exaggerated by writers, as their sagacity certainly has been. This stupidity, unwariness, or liability to demoralizing panic, places them at the mercy of the hunter, who is their only enemy besides the wolves. In former times, young or weak animals straying from the herds, and all the wounded and aged that could be separated from their fellows, were quickly set upon and worried to death by wolves; but now these brutes have become so reduced as not to form a serious check upon their increase.

The early explorers of the Mississippi Valley believed that the buffalo might be made to take the place of the domestic ox in agricultural pursuits, and at the same time yield a fleece of wool equal in quality to that of the sheep; but no persistent attempts have yet been made to utilize it by domestication. That the buffalo-calf may be easily reared and thoroughly tamed has been conclusively proved, but little attention has been paid to their reproduction in confinement, or to training them to labor. During the last century they were domesticated in various parts of the colonies, and interbred with domestic cows, producing a half-breed race which is fertile, and which readily amalgamates with the domestic cattle. The half-breeds are large, fine animals, possessing most of the characteristics of their wild parentage. They can be broken to the yoke, but are not so sober and manageable in their work as the tame breed—sometimes, for instance, making a dash for the nearest water, with disastrous results to the load they are drawing. It is somewhat difficult, also, to make a fence which shall resist the destructive strength of their head and horns. But the efforts at taming buffaloes have not been many or seriously carried on, and no attempt appears to have been made to perpetuate an unmixed domestic race. Probably after a few generations they would lose their natural untractableness, and when castrated would doubtless form superior working-cattle, from their greater size, strength, and natural agility.

"The fate of extermination so surely awaits, sooner or later, the buffalo in its wild state, that its domestication becomes a matter of great interest, and is well worthy the attention of intelligent stock-growers, some of whom should be willing to take a little trouble to perpetuate the pure race in a domestic state. The attempt can be hardly regarded otherwise than as an enterprise that would eventually yield a satisfactory and profitable result, with the possibility of adding another valuable domestic animal to those we now possess."

The precise limit of the range of the buffalo when the first Europeans visited America is still a matter of uncertainty, yet its boundaries at that time can be established with tolerable exactness. It was beyond doubt almost exclusively an animal of the prairies and the woodless plains, ranging only to a limited extent into the forested districts east of the Mississippi River. The results of the present exhaustive inquiries seem to show that its extension to the northward, east of the Mississippi, was limited by the Great Lakes. Contrary to the supposition of several recent writers, Mr. Allen has not been able to find a single mention of its occurrence within the present limits of Canada, New England, or New York State, although the name of the city of Buffalo and the neighboring "Buffalo Creek" probably imply that this animal once extended its travels to that point. All the supposed references to its being seen on the St. Lawrence, or in Canada West, turn out to mean the elk—the same indefinite terms being often used for both by early writers—or else to apply to some part of the broad territory then called Canada, but not now included within its limits. Changes in political boundaries have constantly to be borne in mind in studying ancient narratives.

Furthermore, no remains of the bison have been found among the bones in the shell-heaps along the Atlantic coast, and there is no unquestionable evidence, among all the early lists of the natural products of the country, of its occurrence anywhere on the seaboard north of the Potomac for a long period antedating the discovery of the continent by Europeans. The only well-authenticated instances of its being found east of the Blue Ridge are the apparently casual passage of small herds through the mountains from West Virginia into the upper parts of North and South Carolina by way of the New, Holston, and French Broad Rivers. They seem to have been common on the savannas about the heads of the rivers in the western parts of those States ; but it is well attested that they never came down to the sea-coast. Nor can good evidence be shown that they ever reached any part of Georgia, Florida, or Alabama (although possibly Mississippi), as at present bounded, not appearing habitually to have penetrated south of the Tennessee River—unless just along the bank of the Father of Waters—on account of the thickness of the forest.

The records in general then show, that at the beginning of the seventeenth century the range of the buffalo east of the Mississippi, with the exception of its occasional appearance on the eastern slope of the Alleghanies in the Carolinas and Virginia, was restricted to the area drained by the Ohio River—except over the lowlands at its mouth—and to the eastern tributaries of the Mississippi in northern Wisconsin and Minnesota ; also that it was very numerous and uniformly distributed over the prairies of Illinois and Indiana, and also about the upper tributaries of the Ohio, but less numerously and uniformly over Ohio, West Virginia, Kentucky, western Pennsylvania, and the northern portion of Tennessee, being everywhere restricted to the prairies and scantily wooded land along the streams.

In the appendix Professor Shaler offers a short discussion of the probable age of the bison in the Ohio Valley. In the swamps surrounding the "salt-licks" of Kentucky buffalo-bones are found packed in great quantities in the mucky soil, but only about the latest vents of the saline waters, which have from time to time changed their points of escape from the ground. The caverns of Kentucky and Tennessee, which were the homes of the aboriginal people of the region, and receptacles for their dead, and where have been found skeletons of the beaver, deer, wolf, bear, and many other mammals, have never yielded any bones of the bison. Moreover, among all the many figures of animals and birds found on the pottery and ornaments of the prehistoric races of the West, the marked form of the buffalo does not appear, making it presumable that this animal was unknown to the people who built the mounds. Professor Shaler is of the opinion, held by many ethnologists, that the "mound-builders" were essentially related to the Natchez group of Indians, and were driven southward by ruder tribes of red-men from the north and northwest. The Indians north of the Ohio are known to have been much in the habit of burning the forests, and no doubt the invaders alluded to above signalized their advance by such conflagrations. This making of plains by the repeated burning of forests, aided by "the continued decrease of the rainfall, which was "a concomitant of the disappearance of the glacial period," permitted the buffalo to advance rapidly eastward as far as the Alleghanies, and, coincidently, as far as the mound-building people appear to have settled the country. Its advent thus seems to have been singularly recent.

The question of the origin of the buffalo and its relation to the earliest tribes of people in the Ohio Valley is made still more complicated by the fact that an earlier and closely related species of buffalo, probably coeval with the mammoth and musk-ox, and possibly with the caribou and elk, was living at the time just following the close of the glacial epoch. "I am strongly disposed to think," writes Professor Shaler, "that in the *Bison Americanus* we have the descendant of the *Bison latifrons*, modified by existence in the new conditions of soil and climate to which it was driven by the great changes closing the last ice age." But he adds that future explorations will probably show that there was an interval of some thousands of years between the two species along the Ohio.

Although the main chain of the Rocky Mountains has been supposed commonly to form the western limit of the range of the buffalo, there is abundant proof of its former existence over a vast area west of it, including a large part of the Utah Basin, the Green River plateau, and the plains of the Columbia, westward to the Blue Mountains of Oregon, and the Sierra Nevada. Evidence of this is found in the bleached skulls, in accounts of early explorers, and in traditions of the Indians. During the very severe and snowy winter of 1836–'37 large herds were lost through starvation; by 1840 they had retreated eastward to the forks of the Yellowstone and been extirpated in the Utah Valley and about the head-waters of the Colorado; and ten years later were never to be found west of the Rocky Mountains, between the British possessions and the Rio Grande del Norte. Westward of this great river it does not seem, within the past two centuries, to have extended itself at all into the highlands of New Mexico; but, farther south, there is proof of its former range over the northeastern provinces of Mexico to at least the twenty-fifth parallel, though it was never abundant there, and abandoned that region before the beginning of the current century.

The great center of buffalo-life in ages past was the vast expanse of treeless plains which stretch uninterruptedly from the Texas coasts almost to the Arctic Circle, and here, in restricted areas, they have survived until the present time.

When Cabeça de Vaca met them in 1530 they ranged throughout nearly the whole of Texas, the higher prairie-lands of northwestern Louisiana and Arkansas, and thence uniformly northward and westward. But soon after 1820 they disappeared altogether from Arkansas, and were not seen in western Missouri and southern Iowa later than 1825; but immense herds still roamed over the northern half of the latter State. Since 1845, however, few have been seen anywhere within Iowa, nor did they linger many years longer in Minnesota.

The stream of emigration across the plains to California about 1859 had a curious and permanent effect on the buffaloes. The overland route followed up the Kansas and Platte Rivers, and thence westward by the North Platte to the South Pass. The buffaloes were soon all driven from this line of travel; and the great herd which had stretched from the Rio Grande to the Saskatchewan was permanently divided into two—a northern and a southern herd—which were more and more widely separated by the construction of the Union Pacific Railroad. Year by year since, the limits of the range of each division have been contracting under relentless persecution and the encroachments of civilization, until now they are easily circumscribed. The poor beasts have been hunted by the Indians, have been followed incessantly by white men—professional hunters, sportsmen, hide-seekers, and soldiers—who have been afforded easy access to their haunts by the railroads which have penetrated to their ancient pastures, and been given the means of keeping up the hunt by the nearness of the frontier settlements to the resorts of each herd. Enormous destruction has ensued in Kansas and Colorado, and has had the effect to drive the southern division southward and southwestward into Texas, where hunters can not or (on account of Indians) dare not follow them. They are, therefore, just now (1876) afforded temporary rest from persecution; but, unless legal interference be quickly made and strict regulations rigorously enforced, the fate of the buffalo south of the Platte will be a repetition of its history east of the Mississippi—speedy extermination.

As to the northern herd, while twenty years ago buffaloes were accustomed to frequent the whole region between the Missouri River and the forty-ninth parallel, from the western boundary of Dakota to the Rocky Mountains, and even far into their valleys, they are now restricted to the comparatively small area drained by the southern tributaries of the Yellowstone, and northward over the most of Montana to the Missouri. North of the Missouri River almost a separate subdivision of the herd seems to exist, which feeds between longitude 106° and the Rocky Mountains, and northward to the wooded region of the Athabasca and Peace Rivers. Within thirty years they have become extirpated over half of this fertile region north of our boundary, and their numbers, probably, have correspondingly decreased.

It thus appears that in three quarters of a century the buffalo has been compelled to relinquish a habitat, covering a third of the continent, for two regions not greater together than the present Territories of Montana and Dakota; and they were formerly just as numerous over the whole extent as they now are in favored spots within their range. Hence the theory that they have not been so much reduced in numbers, as they have been circumscribed in range and concentrated upon narrow limits, will not hold good. Over much of this great region they were actually killed on the spot, not driven out.

SHAM ADMIRATION IN LITERATURE.

By JAMES PAYN.

IN all highly civilized communities Pretense is prominent, and sooner or later invades the regions of Literature. In the beginning, this is not altogether to be reprobated; it is the rude homage which Ignorance, conscious of its disgrace, offers to Learning; but after a while, Pretense becomes systematized, gathers strength from numbers and impunity, and rears its head in such a manner as to suggest it has some body and substance belonging to it. In England, literary pretense is more universal than elsewhere from our method of education. When young gentlemen from ten to sixteen are set to study poetry (a subject for which not one in a hundred has the least taste or capability even when he reads it in his own language) in Greek and Latin authors, it is only a natural consequence that their views upon it should be slightly artificial. The youth who objected to the alphabet that it seemed hardly worth while to have gone through so much to have acquired so little, was exceptionally sagacious; the more ordinary lad conceives that what has cost him so much time and trouble, and entailed so many pains and penalties, must needs have something in it, though it has never met his eye. Hence arises our public opinion upon the ancient classics, which I am afraid is somewhat different from (what painters term) the private view. If you take the ordinary admirer of Æschylus, for example—not the scholar, but the man who has had what he believes to be "a liberal education"—and appeal to his opinion upon some passage in a British dramatist, say Shakespeare, it is ten to one that he shows not only ignorance of the author (the odds are twenty to one about *that*), but utter inability to grasp the point in question; it is too deep for him, and especially too subtile. If you are cruel enough to press him, he will unconsciously betray the fact that he has never felt a line of poetry in his life. He honestly believes that the "Seven against Thebes" is one of the greatest works that ever was written, just as a child believes the same of the "Seven Champions of Christendom." A great wit once observed, when bored by the praises of a man who spoke six languages, that he had known a man to speak a dozen, and yet not say a word worth hearing in any one of them. The humor of the remark, as sometimes happens, has caused its wisdom to be underrated; for the fact is that, in very many cases, all the intelligence of which a mind is capable is expended upon the mere acquisition of a foreign language. As to getting anything out of it in the way of ideas, and especially of poetical ones, that is almost never attained. There are, indeed, many who have a special facility for languages, but in their case (with a few exceptions) one may say without uncharity that the acquisition of ideas is not their object, though if they did acquire them they would probably be new ones. The majority of us, however, have much difficulty in surmounting the obstacle of an alien tongue, and when we have done so we are naturally inclined to overrate the advantages thus attained. Every one knows the poor creature who quotes French on all occasions with a certain stress on the accent, designed to arouse a doubt in his hearers as to whether he was not actually born in Paris. *He*, of course, is a low specimen of the class in question, but almost all of us derive a certain intellectual gratification from the mastery of another language, and as we gradually attain to it, whenever we find a meaning we are apt to mistake it for a beauty.* Nay, I am convinced that many admire this or that (even) British poet from the fact that here and there his meaning has gleamed upon them with all the charm that accompanies unexpectedness.

Since classical learning is compulsory with us, this bastard admiration is much more often excited with respect to the Greek and Latin poets. Men may not only go through the whole curriculum of a university education, but take high honors in it, without the least intellectual advantage beyond the acquisition of a few quotations. This is not, of course (good heavens !), because the classics have nothing to teach us in the way of poetical ideas, but simply because to the ordinary mind the acquisition of a poetical idea is very difficult, and when conveyed in a foreign language is impossible. If the same student had given the same time—a monstrous thought, of course, but not impracticable—to the cultivation of Shakespeare and the old dramatists, or even to the more modern English poets and thinkers, he would certainly have got more out of them, though he would have missed the delicate suggestiveness of the Greek aorist and the exquisite subtilties of the particle *de*. Having acquired these last, however, and not for nothing, it is not surprising that he should esteem them very highly, and, being unable to popularize them at dinner-parties and the like, he falls back upon praise of the classics generally.

Such are the circumstances which, more particularly in this country, have led to a wellnigh universal habit of literary lying—of a pretense of admiration for certain works of which in reality we know very little, and for which, if we knew more, we should perhaps care less.

There are certain books which are standard, and as it were planted in the British soil, before which the great majority of us bow the knee and doff the cap with a reverence that, in its ignorance, reminds one of fetich-worship, and, in its affectation, of the passion for high

* Since the above was written, my attention has been called to the following remark of De Quincey: "As must ever be the case with readers not sufficiently masters of a language to bring the true pretensions of a work to any test of feeling, they are for ever mistaking for some pleasure conferred by the writer, what is in fact the pleasure naturally attached to the sense of a difficulty overcome."

art. The works without which, we are told at book-auctions, "no gentleman's library can be considered complete," are especially the objects of this adoration. The "Rambler," for example, is one of them. I was once shut up for a week of snow-storms in a mountain inn, with the "Rambler" and one other publication. The latter was a "Shepherd's Guide," with illustrations of the way in which sheep are marked by their various owners for the purpose of identification: "Cropped near ear, upper key bitted far, a pop on the head and another at the tail head, ritted, and with two red strokes down both shoulders," etc. It was monotonous, but I confess that there were times when I felt it some comfort in having that picture-book to fall back upon, to alternate with the "Rambler."

The essay, like port wine, I have noticed, requires age for its due appreciation. Leigh Hunt's "Indicator" comprises some admirable essays, but the general public have not a word to say for them; it may be urged that that is because they had not read the "Indicator." But why, then, do they praise the "Rambler" and Montaigne? That comforting word, "Mesopotamia," which has been so often alluded to in religious matters, has many a parallel in profane literature.

A good deal of this mock worship is of course due to abject cowardice. A man who says he doesn't like the "Rambler" runs, with some folks, the risk of being thought a fool; but he is sure to be thought that, for something or another, under any circumstances; and, at all events, why should he not content himself, when the "Rambler" is belauded, with holding his tongue and smiling acquiescence? It must be conceded that there are a few persons who really have read the "Rambler," a work, of course, I am merely using as a type of its class. In their young days it was used as a school-book, and thought necessary as a part of polite education; and, as they have read little or nothing since, it is only reasonable that they should stick to their colors. Indeed, the French satirist's boast that he could predicate the views of any man with regard to both worlds, if he were only supplied with the simple data of his age and his income, is quite true in the general with regard to literary taste. Given the age of the ordinary individual—that is to say of the gentleman "fond of books, but who has really no time for reading"—and it is easy enough to guess his literary idols. They are the gods of his youth, and, whether he has been "suckled in a creed outworn" or not, he knows no other. These persons, however, rarely give their opinion about literary matters, except on compulsion; they are harmless and truthful. The tendency of society in general, on the other hand, is not only to praise the "Rambler" which they have not read, but to express a noble scorn for those who have read it and don't like it.

I remember, as a young man, being greatly struck by the independence of character exhibited by Miss Brontë in a certain confession she made in respect to Miss Austen's novels. It was at a period when everybody professed to adore them, and especially the great guns of literature. Walter Scott thought more highly of the genius of the author of "Mansfield Park" even than of that of his favorite, Miss Edgeworth. Macaulay speaks of her as though she were the Eclipse of novelists—"first and the rest nowhere"—though his opinion, it is true, lost something of its force from the contempt he expressed for "the rest," among whom were some much better ones. Dr. Whewell, a very different type of mind, had "Mansfield Park," I believe, read to him on his death-bed. And, indeed, up to the present date, some highly cultured persons of my acquaintance take the same view. They may be very possibly right, but that is no reason why the people who have never read Miss Austen's novels—and very few have—should ape the fashion. Now, the authoress of "Jane Eyre" did not derive much pleasure from the perusal of the works of the other Jane. "I know it's very wrong," she modestly said, "but the fact is I can't read them. They have not got story enough in them to engage my attention. I don't want my blood curdled, but I like it stirred. She strikes me as milk-and-watery, and, to say truth, as dull."

This opinion she has, in effect, repeated in her published writings, but I had only heard her verbal expression of it, and I admired her courage. If she had been a man, struggling, as she then was, for a position in literature, she would not have dared to say half as much. For, what is very curious, the advocates of the classic authors—those I mean whom antiquity has more or less hallowed—instead of pitying those unhappy wights who confess their want of appreciation of them, fly at them with bludgeons, and dance upon their prostrate bodies with clogs.

"For who would rush on a benighted man,
And give him two black eyes for being blind?"

inquires the poet. I answer, "Lots of people," and especially those who worship the pagan divinities of literature. The same thing happens—but *their* fury is more excusable, because they have less natural intelligence—with the lovers of music. Instead of being sorry for the poor folks who have "no ear," and whom "a little music in the evening" bores to extremity, they overwhelm them with reproaches for what is in fact a natural infirmity. "You Goth! you Vandal!" they exclaim, "how contemptible is the creature who has no music in his soul!" Which is really very rude. Even persons who are not musical have their feelings. "Hath not a Jew ears?"—that is to say, though they have "no ear," they understand what is abusive language and resent it.

I am not saying one word against established reputations in literature. The very fact of their being established (even the "Rambler," for example, has its merits) is in their favor; and, indeed, some of the works I shall refer to are masterpieces. My objection is to the sham admiration of them, which does their authors no good (for their circulation is now of no consequence to them), and is injurious not only to modern writers (who are generally made the subject of base comparison), but especially to the utterers of this false coin themselves. One can not tell falsehoods, even about one's views in literature, without injury to one's morals, yet to "tell the truth and shame the devil" is easy, as it would seem, compared with telling the truth and defying the critics.

I have alluded to the intrepidity of Miss Brontë in this matter, and, curiously enough, it is women who have the most courage in the expression of their literary opinions. It may be said, of course, that this is due to the audacity of ignorance, and a well-known line may be quoted (for some people, as I have said, are rude) in which certain angels (who are *not* women) are represented as being afraid to tread in certain places. But I am speaking of women who are great readers. Miss Martineau once confessed to me that she could see no beauties in "Tom Jones." "Of course," she said, "the coarseness disgusts me, but, apart from that, I see no sort of merit in it." "What!" I replied, "no humor, no knowledge of human life?" "No; to me it is a wearisome book."

I disagreed with her very much upon that point, and do so still; yet, apart from the coarseness (which does not disgust everybody, let me tell you), there is a good deal of tedious reading in "Tom Jones." At all events, that expression of opinion from such lips strikes me as noteworthy.

It may here be said that there are many English authors of old date, some of whose beauties are unintelligible except to those who are acquainted with the classics; and "Tom Jones" is one of them. Many of the introductions to the chapters, not to mention a certain travesty of an Homeric battle, must needs be as wearisome to those who are not scholars as the spectacle of a burlesque is to those who have not seen the original play. This is still more the case with our old poets, especially Milton. I very much doubt, in spite of the universal chorus to the contrary, whether "Lycidas" is much admired by readers who are only acquainted with English literature; I am quite sure it never touched their hearts as, for example, "In Memoriam" does.

I once beheld a young lady of great literary taste, and of exquisite sensibility, torn to pieces (figuratively) and trampled upon by a great scholar for venturing to make a comparison between those two poems. Its invocation to the Muses and the general classical air which pervades it had destroyed for her the pathos of "Lycidas," whereas to her antagonist those very imperfections appeared to enhance its beauty. I did not interfere, because the wretch was her husband, and it would have been worse for her if I had, but my sympathies were entirely with her. Her sad fate—for the massacre took place in public—would, I was well aware, have the effect of making people lie worse than ever about Milton. On that same evening, while some folks were talking about Mr. Morris's "Earthly Paradise," I heard a scornful voice exclaim, "Oh! give *me* 'Paradise Lost,'" and with that gentleman I *did* have it out. I promptly subjected him to cross-examination, and drove him to that extremity that he was compelled to admit he had never read a word of Milton for forty years, and even then only in extracts from "Enfield's Speaker."

With Shakespeare—though there is a good deal of lying about *him*—the case is different, and especially with elderly people; for "in their day," as they pathetically term it, Shakespeare was played everywhere, and every one went to the play. They do not read him, but they recollect him; they are well acquainted with his beauties—that is, with the better known of them—and can quote him with manifest appreciation. They are, intellectually, in a position much superior to that of a fashionable lady of my acquaintance who informed me that her daughters were going to the theatre that night to see Shakespeare's "Turning of the Screw."

The writer who has done most, without I suppose intending it, to promote hypocrisy in literature is Macaulay. His "every schoolboy knows" has frightened thousands into pretending to know authors with whom they have not even a bowing acquaintance. It is amazing that a man who had read so much should have written so contemptuously of those who have read but little; one would have thought that the consciousness of superiority would have forbidden such insolence, or that his reading would have been extensive enough to teach him at least how little he had read of what there was to read; since he read some things—works of imagination and humor, for example—to such very little purpose, he might really have bragged a little less. One feels quite grateful to Macaulay, however, for avowing his belief that he was the only man who had read through the "Faerie Queen"; since that exonerates everybody—I do not say from reading it, because the supposition is preposterous—but from the necessity of pretending to have read it. The pleasure derived from that poem to most minds is, I am convinced, analogous to that already spoken of as being imparted by a foreign author: namely, the satisfaction at finding it—in places—intelligible. For the few who possess the poetic faculty it has great beauties, but I observe, from the extracts that appear in poetic selections and the like, that the most tedious and even the most monstrous passages are often the most admired. The case of Spenser in this respect—which does not stand alone in ancient English literature—has a curious parallel in art, where people are positively found to go into ecstasies over a distorted limb or a ludicrous inversion of perspective, simply because it is the work of an old master, who knew no better, or followed the fashion of his time.

Leigh Hunt read the "Faerie Queen," by the by, as almost everything else that has been written in the English tongue, and even Macaulay alludes with rare commendation to his "catholic taste." Of all authors indeed, and probably of all readers, Leigh Hunt had the keenest eye for merit and the warmest appreciation of it wherever found. He was actively engaged in politics, yet was never blind to the genius of an adversary; blameless himself in morals, he could admire the wit of Wycherley; and, a freethinker in religion, he could see both wisdom and beauty in the divines. Moreover, it is immensely to his credit, that this universal knowledge, instead of puffing him up, only moved him to impart it, and that next to the pleasure he took in books was that he derived from teaching others to take pleasure in them. Witness his "Wit and Humor" and his "Imagination and Fancy," to my mind the greatest treasures in the way of handbooks that have ever been offered to students of English literature, and the completest antidotes to pretense in it. How many a time, as a boy, have I pondered over this or that passage in the originals, from Shakespeare to Suckling, and then compared it with the italicized lines in his two volumes, to see whether I had hit upon the beauties; and how often, alas! I hit upon the blots! *

It is curious that Leigh Hunt, whose style has been so severely handled (and, it must be owned, not without some justice) for its affectations, should have been so genuine (although always generous) in his criticisms. It was nothing to him whether an author was old or new; nor did he shrink from any literary comparison between two writers when he thought it appropriate (and he was generally right), notwithstanding all the age and authority that might be at the back of one of them. Thackeray, by the way, a very different writer and thinker, had this same outspoken honesty in the expression of his literary taste. In speaking of the hero of Cooper's five good novels—Leather-Stocking, Hawkeye, etc.—he remarks with quite a noble simplicity, "I think he is better than any of Scott's lot."

It is a "far cry" from the "Faerie Queen" to "Childe Harold," which, reckoning by years, is still a modern poem; yet I wonder how many persons under thirty—even of those who term it "magnificent"—have ever read "Childe Harold"? At one time it was only people under thirty who *had* read it; for poetry to the ordinary reader is the poetry that was popular in his youth—"no other is genuine."

"A dreary, weary poem called the 'Excursion,'
Written in a manner which is my aversion,"

* I remember (when "I was but a little tiny boy") I thought that "the fringed curtains of thine eye advance," addressed by Prospero to Miranda, must needs be a very fine line; imagine, then, my confusion, on referring for corroboration to my "guide, philosopher, and friend," as he truly was, to find this passage: "Why Shakespeare should have condescended to the elaborate nothingness, not to say nonsense, of this metaphor (for what is meant by 'advancing curtains'?) I can not conceive. That is to say, if he did condescend; for it looks very like the interpolation of some pompous declamatory player. Pope has put it into his 'Treatise on the Bathos.'"

is a couplet the frankness of which has always recommended itself to me (though I like the "Excursion"); but, except for the rhyme, it has a fatal facility of application to other long poems. Heaven forbid that I should "with shadowed hint confuse" the faith in a British classic; but, ye gods, how men have gaped (in private) over "Childe Harold"!

"Gil Blas," though not a native classic, is included in the articles of the British literary faith, not as a matter of pious opinion, but *de fide*—a necessity of intellectual salvation. I remember an interview I once had with a boy of letters concerning this immortal work. He is a well-known writer now, but at the time I speak of he was only budding and sprouting in the magazines—a lad of promise, no doubt, but given, if not to kick against authority, to question it, and, what was worse, to question *me* about it, in an embarrassing manner. The natural affability of my disposition had caused him, I suppose, to treat me as his father confessor in literature; and one of the sins of omission he confided to me was in connection with the divine Le Sage.

"I say—about 'Gil Blas,' you know—Bias [a great critic of that day] was saying last night that, if he were to be imprisoned for life with only two books to read, he would choose the Bible and 'Gil Blas.'"

"It is very gratifying to me," said I, wishing to evade my young friend, and also because I had no love for Bias, "that he should have selected the Bible, and all the more so since I should never have expected it of him."

"Yes, papa" (that is what the young dog was wont to call me, though he was no son of mine—far from it); "but about 'Gil Blas'? Is it *really* the next best book? And after he had read it—say, ten times—would he not have been rather sorry that he had not chosen—well, Shakespeare, for instance?"

The picture of Bias with a long white beard, the growth of twenty years, reading that tattered copy of "Gil Blas" in his cell, almost affected me to tears, but I made shift to answer gravely: "Bias is a professional critic, and persons of that class are apt to be a little dogmatic and given to exaggeration. But 'Gil Blas' is a great work. As a picture of the seamy side of human life, of its vices and its weaknesses at least, it is unrivaled. The archbishop—"

"Oh, I know that archbishop—*well*," interrupted my young tormentor. "I sometimes think, if it hadn't been for that archbishop, we should never perhaps have heard of 'Gil Blas.'"

"Tchut, tchut!" said I; "you talk like a child."

"But to read it *all through*, papa—three times, ten times, for all one's life? Poor Mr. Bias!"

"It is a matter of opinion, my dear boy," I said. "Bias has this great advantage over you in literary matters, that he knows what he is talking about, and if he was quite sure—"

"Oh! but he was not quite sure; he was rather doubtful, he said, about one of the books."

"Not the Bible, I do hope?" said I fervently.

"No, about the other. He was not quite sure but that, instead of 'Gil Blas,' he ought to have selected 'Don Quixote.' Now, really that seems to me worse than 'Gil Blas.'"

"You mean less excellent," I rejoined; "you are too young to appreciate the full signification of 'Don Quixote.'"

The scoundrel murmured, "Do you mean to tell me that people read it when they are old?" but I pretended not to hear him. "We do not all of us," I went on, "know what is good for us. Sancho Panza's physician—"

"Oh! I know that physician—*well*, papa. I sometimes think, if it had not been for that physician, perhaps—"

"Hush!" I exclaimed authoritatively; "let us have no flippancy, I beg." And so, with a dead lift, as it were, I got rid of him. He left the room muttering, "But to read it through—three times, ten times, for all one's life?" And I was obliged to confess to myself that such a prolonged course of study, even of "Don Quixote," would have been wearisome.

Rabelais is another article of our literary faith that is certainly subscribed to much more often than believed in. In a certain poem of Mr. Browning's (*I* call it the "Burial of the Book," since the Latin name he has given it is unpronounceable, even if it were possible to recollect it), charmingly humorous, and which is also remarkable for impersonating an inanimate object in verse as Dickens does in prose, there occur these lines:

"Then I went indoors, brought out a loaf,
Half a cheese and a bottle of Chablis,
Lay on the grass, and forgot the oaf
Over a jolly chapter of Rabelais."

Yet I have known some wonder to be expressed (confidentially) as to where he found the "jolly chapter," and the looking for the beauties of Rabelais to be likened to searching in a huge bed of manure for a few heads of asparagus.

I have no quarrel with Bias and Company (though they stick at nothing, and will presently say that I don't care for these books myself), but I venture to think that they are wrong in making dogmas of what are, after all, but matters of literary taste; it is their vehemence and exaggeration which drive the weak to take refuge in falsehood.

A good woman in the country once complained of her step-son, "He will not love his learning, though I beats him with a jack-chain"; and from the application of similar aids to instruction the same result takes place in London. Only here we dissemble and pretend to love it. It is partly in consequence of this that works, not only of acknowledged but genuine excellence, such as those I have been careful to select, are, though so universally praised, so little read. The poor student attempts them, but, failing—from many causes, no doubt, but also sometimes from the fact of their not being there—to find those unrivaled beauties which he has been led to expect in every sentence, he stops short, where he would otherwise have gone on. He says to himself, "I have been deceived," or "I must be a born fool"; whereas he is wrong in both suppositions. I am convinced that the want of popularity of Walter Scott among the rising generation is partly due to this extravagant laudation; and I am much mistaken if another great author, more recently deceased, will not in a few years be added to the ranks of those who are more praised than read from the same cause.

The habit of mere adhesion to received opinion in any matter is most mischievous, for it strikes at the root of independence of thought; and in literature it tends to make the public taste mechanical. It is very seldom that what is called the verdict of posterity (absurdly enough, for are not *we* posterity?) is ever reversed; but it has chanced to happen in a certain case quite lately. The production of "The Iron Chest" upon the stage has once more brought into fashion "Caleb Williams." Now, that is a work, though by no means belonging to the same rank as those to which I have referred, which has a fine old crusted reputation. Time has hallowed it. The great world of readers (who have never read it) used to echo the remark of Bias and Company, that this and that modern work of fiction reminded them—though at an immense distance, of course—of Godwin's masterpiece. I remember Le Fanu's "Uncle Silas," for example (from some similarity, more fanciful perhaps than real, in the isolation of its hero), being thus compared with it. Now, "Caleb Williams" is founded on a very fine conception—one that could only have occurred, perhaps, to a man of genius; the first part of it is well worked out, but toward the middle it grows feeble, and it ends in tediousness and drivel; whereas "Uncle Silas" is good and strong from first to last. Le Fanu has never been so popular as, in my humble judgment, he deserves to be, but of course modern readers were better acquainted with him than with Godwin. Yet nine out of ten were always heard repeating this cuckoo cry about the latter's superiority, until "The Iron Chest" came out, and fashion induced them to read him for themselves; which has very properly changed their opinion.

I remember, in my own case, that, from that mere reverence for authority which I hope I share with my neighbors, I used to speak of "Headlong Hall" and "Crotchet Castle"—both great favorites of our forefathers—with much respect, until one wet day in the country I found myself shut up with them. I won't say what I suffered;

better judges of literature than myself admire them still, I know. I will only remark that *I* don't admire them. I don't say they are the dullest novels ever printed, because that would be invidious, and might do wrong to works of even greater pretensions; but to my mind they are dull.

When Dr. Johnson is free to confess that he does not admire Gray's "Elegy," and Macaulay to avow that he sees little to praise in Dickens and Wordsworth, why should not humbler folks have the courage of their own opinions? They can not possibly be more wrong than Johnson and Macaulay were, and it is surely better to be honest, though it may expose one to some ridicule, than to lie. The more we agree with the verdict of the generations before us on these matters, the more, it is quite true, we are likely to be right; but the agreement should be an honest one. At present very extensive domains in literature are, as it were, inclosed and denied to the public in respect to any free expression of their opinion. "They are splendid, they are faultless," cries the general voice, but the general eye has not beheld them. Nothing, of course, could be more futile than that, with every new generation, our old authors who have won their fame should be arraigned anew at the bar of public criticism; but, on the other hand, there is no reason why the mouths of us poor moderns should be muzzled, and still less that we "should praise with alien lips."

"Until Caldecott's charming illustrations of it made me laugh so much," said a young lady to me the other day, "I confess—though I know it's very stupid of me—I never saw much fun in 'John Gilpin.' She evidently expected a reproof, and when I whispered in her ear "Nor I," her lovely features assumed a look of positive enfranchisement.

"But am I right?" she inquired.

"You are certainly right, my dear young lady," said I, "not to pretend admiration where you don't feel it; as to liking 'John Gilpin,' that is a matter of taste. It has, of course, simplicity to recommend it; but in my own case, though I'm fond of fun, it has never evoked a smile. It has always seemed to me like one of Mr. Joe Miller's stories put into tedious verse."

I really almost thought (and hoped) that that young lady would have kissed me.

"Papa always says it is a free country," she exclaimed, "but I never felt it to be the case before this moment."

For years this beautiful and accomplished creature had locked this awful secret in her innocent breast—that she didn't see much fun in "John Gilpin." "You have given me courage," she said, "to confess something else. Mr. Caldecott has just been illustrating in the same charming manner Goldsmith's 'Elegy on a Mad Dog,' and—I'm very sorry—but I never laughed at *that* before, either. I have pretended to laugh, you know," she added, hastily and apologetically, "hundreds of times."

"I don't doubt it," I replied; "this is not such a free country as your father supposes."

"But am I right?"

"I say nothing about 'right,'" I answered, "except that everybody has a right to his own opinion. For my part, however, I think the 'Mad Dog' better than 'John Gilpin' only because it is shorter."

Whether I was wrong or right in the matter is of no consequence even to myself; the affection and gratitude of that young creature would more than repay me for a much greater mistake, if mistake it is. She protests that I have emancipated her from slavery. She has since talked to me about all sorts of authors, from Sir Philip Sidney to Washington Irving, in a way that would make some people's blood run cold; but it has no such effect upon me—quite the reverse. Of Irving she naïvely remarks that his strokes of humor seem to her to owe much of their success to the rarity of their occurrence: the flashes of fun are spread over pages of dullness, which enhance them, just as a dark night is propitious to fireworks, or the atmosphere of the House of Commons, or a court of law, to a joke. She is often in error, no doubt, but how bright and wholesome such talk is as compared with the platitudes and commonplaces which one hears on all sides in connection with literature!

As a rule, I suppose, even people in society ("the drawing-rooms and the clubs") are not absolutely base, and yet one would really think so, to judge by the fear that is entertained by them of being natural. "I vow to Heaven," says the prince of letter-writers, "that I think the Parrots of Society are more intolerable and mischievous than its Birds of Prey. If ever I destroy myself, it will be in the bitterness of having those infernal and damnable 'good old times' extolled." One is almost tempted to say the same—when one hears their praises come from certain mouths—of the good old books. It is not every one, of course, who has an opinion of his own upon any subject, far less on that of literature, but every one can abstain from expressing an opinion that is not his own. If one has no voice, what possible compensation can there be in becoming an echo? No one, I conclude, would wish to see literature discoursed about in the same pinchbeck and affected style as are painting and music;* yet that is what will happen if this prolific weed of sham admiration is permitted to attain its full growth.—*Nineteenth Century.*

* The slang of art-talk has reached the "young men" in the furniture-warehouses. A friend of mine was recommended a sideboard the other day as not being a Chippendale, but "having a Chippendale *feeling* in it."

THE IMPEDIMENT OF ADIPOSE.—A CELEBRATED CASE.

By E. VALE BLAKE.

FROM the days of Hippocrates, intelligent medical observers have noticed that an unusual accumulation of fat, far from adding to the strength of a person, was a source of physical weakness, and, to a certain extent, an outward sign of incapacity; that it limited activity and shortened life. It is only in comparatively modern times that scientific experimentalists have ascertained precisely how the system generally, and the heart particularly, is affected either by the overloading or infiltration of superfluous fatty matter upon or in its muscular substance. In fact, it was not until the microscope was carefully applied to the investigation that the disease now known as "fatty degeneration" was really understood.

Every one knows that a certain amount of adipose matter in the human system impedes rapidity of motion. No sportsman would back a pedestrian who turned the scale at three hundred pounds, for instance; but there are other kinds of impedimenta to the human faculties which are certainly to be traced to superfluous fat, though this is rarely suspected of being the cause. A common case is that of the obese gourmand who complains that nothing tastes as it used to; on whose palate, formerly so sensitive, everything palls, and fails to awaken the delicious sensations of former days. He is very apt to attribute the change to the incompetent *chef de cuisine*, or even to degenerate Nature herself, in not growing the same quality in bird or fish; while the looker-on is apt to imagine that the change results from mere satiety. But suppose we had our fat friend on the dissecting-table, what should we probably find? No doubt, insidious deposits of fatty matter which have impeded the lively sensations of the organs of taste and smell, the latter of which so greatly aids the imagination and assists in the pleasure of the table. In the "Medico-Chirurgical Transactions," of 1870, Dr. W. Ogle gives five distinct cases of *anosmia* arising from an excess of fatty deposit permeating the cells of the olfactory apparatus.

Still more curious, and as generally unsuspected, is the deposit of adipose tissue as a cause of deafness; and this not directly in the organs of hearing, but in the canals leading to the air-passages of the nose and throat. This naturally requires some explanation to non-professionals, though the fact is well established. It results from the sympathetic connection which is formed by the continuous mucous membrane, which covers at once the interior of the mouth and throat, the pendulous palate, the tonsils, the isthmus of the fauces, and the pharynx, etc.; this same web of membrane is carried to the Eustachian tubes (which lead from the back part of the mouth to the cavity of the ear), and thus it is that what only visibly affects one portion, say the lachrymal canal, or the tonsils, may sympathetically disorder the sense of taste or hearing. The substance of this mucous membrane is composed of three layers, containing a cellular or folliculous system of roundish or oval cells, which are subject to morbid alterations, that affect parts far removed from the local appearance of disorder. Thus, Dr. Harvey reports : "I have seen and treated many cases of deafness which appeared to depend solely on nasal obstruction from adipose deposit. It does this by interfering with or impeding the entrance of the air to the mouth of the Eustachian tubes, undue limitation of air lessening the sensibility and acuteness of the auditory organ. These cases usually occur in persons of great corpulence, in which case local treatment is almost valueless. The corpulence itself must be reduced."

We might go on and point out many physical ills which result from obesity, and we will name a few ; but our principal object in these pages is to show that a *redundance of adipose matter essentially weakens and impedes the power of the will.* We know that it disinclines to activity, produces shortness of breath, palpitation of the heart, and comparative weakness in proportion to size, and is often accompanied by anæmia. We can make this clearer, perhaps, by an illustration. The normal weight of a man five feet in height is 120 pounds ; of a man five feet ten inches, 169 pounds. Now, suppose the latter really weighs 300 pounds by accumulation of fat, what results but that all this superfluous matter has to be supplied with capillaries, and these have to get blood from vessels only constructed to circulate the original quantity ? No wonder is it that the circulation is enfeebled and impeded ! By this increase of adipose there is no increase of propelling force. Hence, the overstrain upon the capillaries and the ensuing comparative weakness in the vital functions are explained, and also why external injuries are less easily repaired.

It is a well-settled rule in all animal structures that, when the quantity of fat exceeds the law of their construction, bulk becomes a source of imperfect equilibrium, and therefore of danger. The most bulky animals are not the most useful nor the strongest. An elephant compared with its size is not as strong as an ant. Then there is this physiological fact, that the oleaginous principle is actually less alive than any other part of an animal. Observe the blubber of a whale, into which parasites bore an inch deep without causing any inconvenience, and into which a harpoon may be thrust without serious injury if it does not penetrate to the muscular substance. The quantity of fatty matter in animals seems to bear an inverse relation to the quantity of bodily and mental activity. Hibernating animals, who may be said to live on their own fat, are the perfection of indolence. All shepherds know that a very fat ewe will not produce a strong lamb.

Some Brahmans pride themselves on their obesity—did one of them ever run a race, or write a book? Chesterfield said that fat and stupidity were such inseparable companions that they might be used as convertible terms. We should not be willing to indorse that opinion exactly; but, if he had said fat and inactivity, he would not be far wrong—though we have seen exceptions even to this. But it is undoubtedly true as a rule. Carnivorous animals that have to earn their dinners are generally thin; domestic ruminants are fat. Animals shut up in cages either pine and die or get fat. At Strasburg, famous for *pâté-de-fois-gras*, geese are shut up in warm coops and overfed to produce the fat (and diseased) livers so much admired by gourmets. In Italy, wealthy connoisseurs are very fond of fat ortolans, and this is the device by which they obtain them: They shut the birds up in a dark chamber, (knowing that in their natural state it is their habit to feed at sunrise). They then arrange artificial lights which can be cast at will into the dark prison of the birds, on seeing which the ortolans immediately seek the food which is provided for them; the light is withdrawn, and they go to sleep; after a few hours it is again introduced, and so the process is repeated five or six times in the twenty-four hours, so that the birds are kept constantly feeding or sleeping; the consequence is, that in about three days the ortolan becomes "a delicious ball of fat," and ready for the table.

In the human being there is, however, a difference, just as there is in the domesticated animals; there is what is known as "good fat," which must not of course be too redundant, and "bad fat." The fat of the florid person may generally be classed with the good, that of the flabby anæmiac with the bad: the latter is recognized in the unwholesome look of the chronic victim of alcohol.

But, to turn from the purely physical aspects of adipose, we wish to invite the reader's attention to a celebrated case of the impediment of adipose in affecting the mental character, and the action or inaction superinduced by this malady.

One of Shakespeare's famous characters—we should say perhaps his supreme portrait—is described thus with one dash of the pen:

"*He's fat and scant of breath!*"

The character of Hamlet has suffered such constant distortion at the hands of commentators, and has been made unintelligible and mysterious through a very natural but fatal oversight, namely, the habitual neglect of the annotators to take into the account the physical organization of the Danish Prince—an oversight which the poet never made. He never failed to make the *physique* conform to the character.

Every shade of capacity and ingenuity has been expended on the consideration and explanation of Hamlet's mental traits, but unfortunately with an essential factor left out. Not one, of all the numerous writers who have essayed to enlighten the world on the meaning and intent of this "consummate flower" of the poetic insight, has thought to inquire whether the body was not that "unknown quantity" which confounded Schlegel, and which Goethe thought he had found in the lines—

> "The time is out of joint; O cursed spite!
> That ever I was born to set it right!"—

that is, that the Prince was overborne by the too great pressure of an Herculean task with which he was conscious he had not the ability to cope. But that there was really no insufficiency of mental power appears patent at every forward movement of the play. He perceives the situation clearly, argues about it rationally, notes all the circumstances, and acknowledges his own duty in the premises; but he does not *do* the thing which he sets before himself to perform.

Why? Because "he's fat and scant of breath"—in other words, is weighted down with a non-executive or lymphatic temperament.

Painters, as well as actors, have done much to foist a false Hamlet upon the public imagination. He has habitually been represented by both as possessing a nervous, bilious, saturnine temperament, for which there is no warrant in the poet's description of him. Artists have portrayed him as fleshless and dark-hued. Fechter, the sole exception, did indeed remember his nationality to the extent of introducing the novelty of a flaxen wig, which was barely tolerated by the audience, so counter to the truth was the ill-taught popular fancy. But who has yet dared, on canvas or on the stage, to present a true Shakespearean Hamlet "grunting and sweating under his weary load of life"?—so fat really as to need that "napkin" which the queen offers him to wipe the perspiration from his brow.*

Yet is this "fat" the keynote and solution of the "mystery of Hamlet."

Remembering that he was fat and scant of breath, we can readily understand many things which are otherwise certainly perplexing; particularly the inconsistency between his thoughts and desires and his chronic inaction. He would represent in modern life those persons whose cerebral developments are put down at maximum figures by the expert phrenologist, and who exhibit to admiring friends their large brain-power as thus indicated, but who never do anything to confirm the diagnosis. Again, why? because they lack the energizing temperament without which the brain is but a dumb mass of latent possibilities.

* Profuse perspiration is a recognized symptom of one form of heart-disease—endocarditis.

The character of Hamlet is generally conceded to be the most wonderful production amid all that vast galaxy of dramatic figures which has enchanted the world for three hundred years, and if one new to the subject inquires why it thus takes precedence of Lear, Othello, Macbeth, Shylock, and their proximate peers, we must first answer negatively that it is not because there is so much deeper philosophy in Hamlet than may be found, scattered pearl-like, throughout all the plays by the same master hand, nor because any single passion is therein better delineated—but, affirmatively, because in the Prince of Denmark there is combined the greatest complexity of mental acumen, allied to an unparalleled variety of passional influxes, and bound, alas! to an inefficient temperament. It is not one master passion which stirs, nor one affection alone that is outraged; not one sole grief that afflicts, or one emotion which reigns supreme over that great but erratic mind: it is a commingling of jarring elements, most difficult to reconcile in the formation of a characteristic individuality.

In the rising tide of the Moor's jealousy we have the most vivid description of a half-savage tornado of mental suffering, produced by the uncontrolled agonies of a strong but simple and ill-balanced mind; in Lear, an already tottering intellect, quite overthrown by the cruel irritations of unimagined ingratitude; in Macbeth, an unsafe ambition troubled with a conscience; in Shylock, a member of an outraged race, essaying an hereditary revenge, stimulated by avarice: but in Hamlet we have a whole circle of passions, a complication of emotions to draw into one converging action, like an engine required to run on a main road with many branches, and no steam in the boiler.

To particularize: there is first his natural sorrow for the death of his father; sorrow, anger, and chagrin at the hasty marriage of his mother; hatred and suspicion of his uncle; his loss of the crown of Denmark for an indefinite time; the necessity for concealing his suspicions as to the "taking off" of the King; the perplexing and terrifying impressions produced by the vision of the ghost; its adjuration to active revenge; his love for Ophelia, and its interruption apparently at her own caprice; the annoying surveillance of old Polonius; distrust of his old school friends, Guildenstern and Rosencrantz; the voluntary assumption of the rôle of madness, and the necessity of combining this with the retention of his true mental status with certain of his friends; his unintended injury of Ophelia and her brother through his "brainish" homicide of their father, when he had hoped to slay the King; the distressing madness and death of Ophelia, with her scanty burial rites—imperiling her soul, in the common opinion of the time; the encounter with the irate Laertes: all these and minor complications and difficulties were thrust upon him, a situation scarcely to be successfully encountered by a soul incased in the very fittest framework which nature ever contrived as its instrument for setting a disjointed world to rights—by one whose blood and judgment were so well commingled that every thought is not only wise and just but also briefly precedent to action.

Now, what has our Shakespeare done in this masterpiece of dramatic composition, but *allied all these untoward events and tempestuous emotions of a great, grieved soul to a body physically unadapted to success?*

This is the "mystery of Hamlet," and the world has been long making the discovery.

Hamlet's "too too solid flesh" caused him to procrastinate. Had it not been for that weight of adipose substance he "were simply the most active fellow in Europe"; but the inertia of fat was like gyves upon his hands and feet, and could not be overcome except under extraordinary provocation, and then, the sudden impulse subsided, flagged again, mastered by the chronic habit of (let us give the right word, though the heavens fall!)—laziness!—the result of his "fatty degeneration."

We know that we have to encounter the settled prejudices of the world against us in this view of the character of Hamlet. We certainly had our own preconceived notions to conquer before arriving at this conviction; but a close examination of the text undoubtedly bears it out, and indeed we can see no other satisfactory solution of the problem offered, by the contradictions of the clear reasonings and the muddled deeds of the Prince of Denmark.

That the above scientific but simple explanation has not been previously reached by some one of the many keen and learned critics of the play, is only to be accounted for by the transcendent attraction of the intellectual traits displayed therein. The pivotal point in nearly all these discussions being the question whether the dramatist really intended to portray an assumed or real insanity—and certainly, ignoring the theory we now propound, that must ever remain a mooted point; but, admitting the dominant power of his "too solid flesh," every apparent inconsistency is accounted for.

In the very first scene of the first act we get an intimation, though no description, of Hamlet's physical temperament. Why, we may well ask, should the poet represent the Ghost as first appearing to certain officers of the guard, to whom it had no communication to make, and to whom none was necessary, unless it was to show a certain lack of sensitiveness to spiritual influences in the Prince, an absence of that refinement of nerve which originates, by attraction, spiritual influences? This preliminary stalking suggests a certain grossness of material texture in the Prince not present, for instance, in Horatio. The son of the royal Dane needed, it seems, a better attuned medium to put him *en rapport* with his own father's spirit. Here we have the first intimation, a sort of prelude as it were, amply borne out by the succeeding events, that in everything which was to be really accomplished others must take the initiative. The very expression which Hamlet uses in that frenzied burst of passion on parting with the Ghost, "While memory holds a seat in this distracted *globe*," is suggestive of a rotund and corpulent person. We can not conceive of the phrase-culling poet applying it to the narrow *caput*, for instance, of Master Slender, but must believe that Shakespeare kept well in mind the *personnel* of his hero; in fact, when did he ever forget that important item in the description of his creations! Indeed we are very soon again reminded of the characteristic physical development of the Prince by the expression Ophelia makes use of when she applies the term "bulk" in her sad description of Hamlet's visit to her closet.

> "He raised a sigh * so piteous and profound
> As it did seem to shatter all his *bulk*."

Bulk! the very word Shakespeare employs to describe the ponderous Wolsey—"His very *bulk* take up the rays o' the beneficial sun."

Ophelia had taken an accurate survey—she notes the disorder of his garments, mentions that he is pale (a symptom of anæmic adipose), but gives no hint that he has "fallen away vilely," which would have been the first thing to attract the attention of a young lady who believed one mad for the love of her. No, his "bulk" is evidently undiminished either by love or lunacy.

As with Ophelia, so with all the persons who address or describe him, none make any comment which would suggest a thin or haggard appearance. When Polonius describes to the King the course of the seeming madness, he confines himself exclusively to the mental analysis, and makes no mention that the Prince's body has succumbed to the malady. When the King drinks to him, it is not to his better health or better wits, but to his "better breath"! And the Queen-mother, watching him anxiously during the passage-at-arms with Laertes, makes the exclamation which we have taken as the keynote of our theory, "He's fat and scant of breath." And then, with instinctive maternal tenderness calls to him, "Here, Hamlet, take my napkin, rub thy brow"; which he not heeding, she repeats, "Come, let me wipe thy face."

Can we not see the perspiration trickling over the broad, heavy cheeks as we read these lines? It was surely from experience that he spoke of "sweating and grunting under a weary life."

That he is consciously represented as feeling the impediment of the weight of his own flesh is clearly discerned by the frequent references to it. A gaunt, thin, wiry, or even an ordinary muscular man, would not be apt to describe his flesh as "too solid," or to enumerate as one of the serious ills of humanity "the *grunting* and sweating under

* Medical men indicate frequent sighing as a sign of heart-disease, caused by superfluous fat.

burdens." In Hamlet's description of himself to Guildenstern, where he says he "has lost all his mirth," and so forth, it is still the dejection of his mind which he puts forward: he does not pretend to excite sympathy by pointing to his failing body. So in his complimentary address to Horatio, who appears to him to be so fortunately endowed, physically and mentally, he recognizes in his friend that favorable constitution where the blood and will power are so equably adjusted that they "are not a pipe for Fortune's finger to sound what stop she please." In other words, Horatio was seen to possess what the speaker was conscious of lacking, a constitution in which the body is subordinate to the will, a temperament which Hamlet had not, but quite the reverse—in which the will was dominated by the body. This he vaguely feels but can not explain, and so he soliloquizes:

> "I do not know why yet I live to say
> This thing's to do"—

except that he was a "muddy-metalled rascal"; but we perceive clearly enough that it was not his brain but his body which was muddy-metalled.

Again, he evidently feels the drag-anchor of his heavy mold, and the consequent ill-coöperation of his bodily frame with his discerning spirit, when even under great excitement he stops to explain that he "is not splenetic and rash," though yet there is a sort of ground-swell of "something dangerous" in him. Yes, dangerous if sufficiently aroused; but his was a kind of nature which could endure a great deal of arousing before it culminated in action. When he takes his leisurely walk in the hall this quiet exercise goes under no other name with him than a "breathing-time"; and, once familiarized with his true physical picture, how apt appears his reply to Osric: "Sir, I will walk here in the hall; if it please his Majesty, this is the *breathing-time* of day with me."

When he apologizes to Laertes, he says, "You must needs have heard how I am punished with a sore distraction." He says "heard," because he is conscious that there is nothing in his appearance to indicate failing health, and this under the circumstances he would scarcely have omitted had he lost any of his superfluous flesh. He was himself a keen observer of physiological peculiarities, was ready enough to detect changes in the personal appearance of others, and therefore would have been thoroughly conscious of his own had any marked falling away taken place. Notice his reception of the players. One he addresses thus:

> "O old friend, why thy face
> Is valanced [wrinkled] since I saw thee last."

And to her who is to play the Queen—

"By'r lady,
Your ladyship's nearer to heaven
Than when I saw you last, by
The altitude of a chopine." *

An executive temperament would have needed no other incitement, one would think, to action than the reproving adjuration of the ghostly visitant.

"Duller than the fat weed
That rots itself at ease on Lethe's wharf"

must that son have been who could passively subside after such a nocturnal interview; yet Hamlet stops, considers, hesitates, questions, and —does nothing. Not from any thought that it was a crime to revenge even a father's murder by killing another; no, for he deliberately postpones the most favorable opportunity of revenge which occurs, that he may at some future time insure the killing of his uncle's soul, as well as his body, by taking him, if possible, while he was about some act "that had no relish of salvation in't."

To conceal from himself the evident pusillanimity of his course he assumes the rôle of lunacy, which required no violent exertion and afforded ample time for meditation, delay, and the use of other persons to accomplish his ends. It seems also a cover for cowardice, in that he expects the mantle of his assumed malady to cover him from blame in the execution of that long-considered vengeance he is never destined to take; for, when at last he does stab the King, there is no thought of his father in his mind; it is but the reprisal for later treacheries aimed at his own life. This rôle of madness, however, only causes a stricter watch to be put upon him; nor does it help him forward one step toward the fulfillment of the Ghost's injunction. The accidental arrival of the players is indeed seized upon and applied by him to the purpose of testing the truth of the ghostly asseverations; but he had evidently never thought of sending for them, for the purpose of questioning the King's conscience—the opportunity was thrust upon him.

The moment of confusion which ensues at the *dénouement* of that plot, when the King arises in remorseful perturbation, would have seemed to furnish the precise instant when vengeance would have been commended by justice; but the unequaled opportunity is allowed to pass with merely a satirical jest.

That Hamlet meant to slay the King, when he really killed Polonius, is but cumulative evidence that the excitement of the interview with his mother (sought by her, not him) was the immediate cause of his rash and ill-directed act. It was not premeditated, and required no courage, as the party behind the tapestry had no opportunity of defense, and the act can scarcely be considered as part of his settled pur-

* *Chopine*, a high-heeled shoe, or clog.

pose to revenge his father's death. Like all persons of a lymphatic temperament, Hamlet could be suddenly aroused to a high pitch of daring, but was utterly incapable of persistent effort. He follows the Ghost to the edge of the cliff in defiance of the warnings of his companions, threatening to "make a ghost of him that lets me"—he could make a sudden stab in the hangings of his mother's apartment—could leap into the grave with Laertes, and outrave the latter's frenzied demonstration, with the self-asserted passion of "forty thousand brothers," but it was soon over. The immediate cause of excitement being removed, he returns to his natural inactivity.

The episode of the voyage to England at the instance of the King, submitted to without protest, is a terrible descent from the sublime grandeur of his philosophizing and thunderous threats. A tame passivity rules him; but, discovering the imminence of his danger on the voyage, there is revealed a cunning cruelty in his nature that the brave, active man would have scorned. But persons who are noted for their general inertia, when they do move, are very liable to astonish by the intensity and unexpected turn of their action.

Once again, toward the close of the play, we get another insight into the torpid constitution of the Prince. In the preliminary discussion with Horatio as to his fitness for the duel with Laertes, his friend says:

"You will lose the wager, my lord."

And Hamlet replies: "No, I shall win at the odds; but thou wouldst not think *how ill all's here about my heart;* but it's no matter." Just such an answer as a person might make who was suffering from "fatty degeneration." Evidently, in the opinion of the writer, the consideration of the unpleasant possibilities of the duel had brought the action of the heart almost to a standstill—the result of a chronic, sluggish circulatory system. Had his blood been accelerated, as would naturally have occurred in a nervous temperament, other expressions would have been more fitting; but the phrase above quoted better indicates partial stagnation than anything else. His philosophy, indeed, "defies augury," but his physical organization can not choose but respond to the near presence of a fatal venture. With the one not surprising exception of the first sight of the Ghost, Hamlet is throughout like the obese class generally which he represents, sufficiently careful of his personal safety. He puts himself to no bodily risk. In leaping into the open grave after Laertes, it must be remembered that he is on his native heath, as it were, surrounded by friends, while the unfortunate brother is the alien and unwelcome guest; and the apparent calmness but real tremor with which he accepts the invitation to a passage at arms is painfully betrayed by the abnormal action of the heart above referred to: besides, in that age it required more courage to decline a duel than to accept one.

The medley of the last scene, including the death of the King, though the latter is finally slain by Hamlet, is all brought about by the management of other heads and hands, and its conclusion evidently unforeseen by the Prince. From first to last he accomplishes nothing of set purpose. He moralizes by temperament and habit, but *acts only when inaction is the more difficult resource.* The fine spirit, the clear insight, the keen reader of other men's thoughts, is *imprisoned in walls of adipose*, and the desire for action dies out with the utterance of wise maxims, philosophic doubts, and morbid upbraidings of his own inertness. Hamlet is like one of those persons (to be met with in every community) who can relieve themselves by talking. This is a kind of character well understood by Shakespeare. In the third Richard's conference with the murderers of Clarence, one replies to him :

> "Tut, tut, my lord, we will not stand to prate ;
> Talkers are no great doers."

Again, in describing a character the very opposite to that of Hamlet —one of few words, Cordelia—the poet makes her say, "What I well intend, I'll do't *before* I speak." Now, of all the characters drawn by Shakespeare, Hamlet is preëminently the man of words ; not only his famous soliloquies but his dialogues take up unwonted space ; he is the most prolific moralizer of the dramatist's conception, and thus all practical manhood is allowed to ooze out in words.

To judge the better whether Shakespeare intended in this play to show how the body may clog the aspirations of the mind, we have only to observe that whenever the physical appearance of any character is described by him, we find that leanness is an element of the executive man, and "bulk" or fatness of the dilatory and procrastinating, just as we see it in every-day life. Says Prince Henry to Falstaff :

> "What! stand'st thou idle here? Lend me thy sword!"

And the fat knight replies :

> "O Hal, I prithee give me leave to *breathe* awhile"—

the very expression used by both the King and Queen in regard to Hamlet, and in which he also describes his own case.

On another occasion Prince John addresses the pseudo-hero of Salisbury Plain :

> "Now, Falstaff, where have you been all this while?
> —When everything is ended, then you come."

And the inimitable old rogue, knowing that he must be pardoned for his fat, answers :

> "Do you think me a swallow, an arrow, a bullet?"

So also Cæsar, recognizing the physiological improbability of a fat man actually carrying out a treasonable conspiracy, says :

> "Let me have men about me that are fat."

And of Cassius—

"Would he were fatter!
If my name were liable to fear,
I do not know the man I should avoid
As soon as that spare Cassius."

Macbeth was not fat, nor Richard III., nor Henry V., nor Harry Hotspur. They did the things which they planned to do. They did not have to stop to "breathe" themselves like the Prince of Denmark. Who can possibly conceive of a fat Coriolanus? The fat man may be greedy and avaricious like Cardinal Wolsey, or witty and sensual like old Jack, or brooding and melancholy like Hamlet; but he who can vault into his saddle "like feathered Mercury" will ever win the day by action.

Hamlet's uncle-father might confidently have left the unhappy philosopher to his questionings and musings; had he not set his own trap he might have finished his reign in safety, if not in peace, for the Hamlet of Shakespeare, unlike the real Hamlet of Saxo Grammaticus, would no more have set the palace on fire than he would have produced a conflagration of the Skager Rack—for he was "fat and scant of breath," impeded at every step by a superfluity of adipose.

THE MARTYRDOM OF SCIENCE.

By J. W. SLATER.

THE history of human progress presents no feature more interesting yet more commonly overlooked and misrepresented than the treatment of discoverers and inventors. That these men have, as a rule, fared ill at the hands of their species is carelessly or grudgingly admitted. But the questions by whom have they been persecuted, and what may have been the motive of their enemies, are avoided even in works where we might expect them to be carefully discussed and fully answered. Such omission may be especially charged against Sir D. Brewster. His treatise is merely a biography of certain astronomers who have been, for anything the reader learns to the contrary, incidentally and casually afflicted by their contemporaries, and it omits the most striking instances of persecution. Nay, the very term "martyrs of science" is applied quite vaguely, and is made, e. g., in the work of M. Tissandier, to include three distinct classes of men. We have on the one hand personages whose love for research has cost them health and even life itself. We find physicists like Richmann, chemists like Gehlen, Mansfield, Chapman, who have been struck dead while engaged in some hazardous experiment. We read of naturalists like Marcgrave and the elder Wallace, geographers, navigators, and travelers, such as Cook, La Perouse, Franklin, Livingstone, meteorologists like Crocé-Spinelli, who in their ardor for discovery have succumbed to ungenial climates, to the attacks of savages, to hunger, tempest, or to an irrespirable atmosphere. All honor to these men, and to the noble army of which they may be taken as representatives! They have fallen in the cause of science, but they have undergone no persecution, and may hence be regarded as victims rather than martyrs.

We turn to another class: illustrious inventors and discoverers not a few have been clearly and decidedly persecuted; hunted down by mob-violence, imprisoned, or even judicially murdered; but these inflictions are to be traced not to their scientific discoveries, speculations, and writings, but to their religious or political opinions. When the house of Priestley was sacked and burned by the rabble of Birmingham, and when his very life was endangered, it was not the chemist and physicist but the so-called "Jacobin" and Socinian whom Midland roughdom sought to crush. It is not, we believe, generally known that the attack on Priestley's house was headed by the town-crier, a man of the name of Sugar, who rang his bell and exclaimed:

> "Pile up the wood higher,
> I am Sugar, the crier;
> By my desire
> This place was set on fire!"

This man and his doggerel are only worth our notice as proof of the official countenance lent to the outrage. It is utterly incredible that a town-crier would thus avowedly act as the ringleader of a mob unless sure of the connivance of his superiors.

If Campanella was put seven times to the torture, on one occasion for forty hours in succession; if he passed twenty-seven of the best years of his life in loathsome dungeons; if, after his release, he narrowly escaped the rage of a brutal populace, it was not as the champion of the Copernican system of astronomy, the refuter of mediæval Aristotelianism, but as a patriot who longed to deliver southern Italy from the tyranny of Spain, that he suffered. Still we may concede that like all the reformers of science he must have aroused the hatred and jealousy of many of the learned, who would doubtless use against him whatever influence they possessed.

Servetus was certainly a learned physician, and is by some ranked as one of the forerunners of Harvey. But his judicial murder by Calvin was due solely to his theological opinions. The merits of Bernard Palissy, not merely as the creator of modern fictile art, but as an able physicist, chemist, and geologist, can not be contested. He shocked the philosophasters and sophists of his day by maintaining that fossil shells were not, as was then supposed, mere freaks of Nature, but the remains of extinct animals. He dared to deny that stones were capable of growth. He pointed out the possibility of artesian wells. With an almost prophetic insight he foretold the evil consequences of the destruction of forests, and in our day not merely meteorologists and farmers, but governments find that he was in the right. But in spite of all his innovations in science and in industrial art—or rather in consequence of those very innovations—he was honored and protected by Catherine of Medicis and Henry III. That he was at last arrested, condemned to death, and allowed to die in the Bastile, was the consequence of his firm adherence to the doctrines of the Huguenots. Had it not been for his scientific greatness he would have perished earlier.

If Lavoisier perished on the scaffold amid the storms of the first Revolution, he merely shared the fate of his colleagues the *fermiers généraux*, none of whom were men of science. It is true that "the brutish idiot into whose hands the destinies of France had then fallen," as Professor Whewell justly remarks, declared that "the republic had no need of chemists." But these foolish words give us no right to assert, as a modern writer has done, that Lavoisier suffered death for his chemical ideas.

If Bailly likewise perished upon the scaffold, and if Condorcet poisoned himself to escape a similar fate, they died not as philosophers and mathematicians, but as victims of indiscriminate popular frenzy.

There are many other men whose names we are thus compelled to erase from the list of the martyrs of science—men whose inventions and discoveries have been of the highest order, but whose sufferings and death can not be justly looked on as a consequence of their achievements.

But there still remains a third and a too numerous class: thinkers and discoverers who have been persecuted in many cases to the death, not incidentally, but because of the very services they have rendered to science. Their persecutions have differed very much in nature and degree according to the age and the country in which they lived. In the dark ages it was practicable to arrest a troublesome thinker and to put an end to his researches, or at least to their promulgation, by the straightforward means of imprisonment, torture, banishment, and even death at the stake. Hypatia, of Alexandria, was seized by a mob of infuriated monks, who literally tore the flesh from her bones with fragments of pots, dragged her mangled remains outside the city, and there burned them. The Bishop Cyril, who had instigated the outrage, endeavored to screen the malefactors from justice. Virgilius, Bishop of Salzburg, was burned by Boniface, the papal legate, for asserting the existence of antipodes. Cornelius Agrippa, after much persecution, died at last of actual famine. Roger Bacon, perhaps the mightiest philosopher of the middle ages, of whom it has even been said that could he revisit the earth he would shake his head at the slowness of our progress since his death, suffered bitterly. He was first prohibited from lecturing at the University of Oxford and from communicating his researches to any one. The accession of Clemens IV. to the papal chair gave the illustrious sage a short respite, of which he availed himself to draw up three works, and to publish one of them, the "Opus Majus." Scarcely was this effected when the enlightened Pontiff died, and his successor was indifferent, if not formally hostile. Roger Bacon was summoned to appear at Paris before the legate Jerome of Ascoli, was convicted of heresy and witchcraft, and sentenced to imprisonment for life. His works were also condemned as impious, and all persons were forbidden to read them under pain of excommunication. It is certain that he remained ten years in a loathsome dungeon, and that his treatment, even in that rude age, was considered exceptionally harsh. Some say that he died in prison; others, that he was at length set free at the intercession of certain powerful nobles, and ended his days in England. He is said to lie buried at Oxford. We can wish that ancient university no greater boon than that his spirit may ever rest upon its professors.

Three centuries later Rome witnessed one of the foulest murders ever committed. Giordano Bruno, for upholding the teachings of modern astronomy, and especially for maintaining the immensity of the universe and the plurality of worlds, was burned to death in the Campo di Fiore on February 16, 1600. The words of the sentence passed upon him are significant: "Ut quam clementissime et citra sanguinis effusionem puniretur." Not less memorable was the reply of the hero-philosopher: "You feel more fear in pronouncing this sentence than I do in receiving it!"

One of the greatest merits of Bruno is his enunciation of the doctrine that on all scientific questions the Scriptures neither possess nor claim any authority, but embody merely the opinions current at the times when they were written. This proposition, from which follows as a corollary that the Church can have no claim to pronounce on the truth or falsehood of scientific theories, was afterward enforced at length by Galileo in his celebrated letter to the Dowager Grand Duchess Cristina of Tuscany. We can not help regretting that he, when brought before the inquisitors in the Convent of Minerva, did not act up to his profession by denying *in toto* the authority of the court. Had he done so his life would doubtless have been in great peril, but the enemies of science would have been deprived of much scope for sophistry. "E pur si muove" was well, but "non coram judice" would have been infinitely better. It is worthy of note that, unless we are misinformed, St. Augustine had warned the clergy against the attempt to exercise a jurisdiction over science.

As we approach modern times a change becomes manifest. Ecclesiastical bodies in the more civilized parts of Europe were deprived of civil power, and could no longer imprison, torture, or burn inventors and discoverers. But the old spirit faded away very slowly, and even in our days it still occasionally comes to light. Men of science, scientific works, and learned societies were, and still are, traduced, denounced, and held up to public hatred. Scarcely a capital step has been taken in any branch of research but it has been branded as atheistic. Dean Wren, the father of the celebrated architect, upheld the geocentric theory of the universe and the immovability of the earth in a strain worthy of Caccini or Scioppius. It was objected against the Royal Society that its "members neglected the wiser and more discerning ancients and sought the guidance of their own unassisted judgments, and that by admitting among them men of all countries and religions they endangered the stability of the English Church." It was urged that experimental philosophy was likely to lead to the overthrow of Christianity, and even to atheism. Among these writers a prominent place belongs to Henry Stubbs, of Warwick, and the Rev. Richard Cross, of Somerset, the latter of whom charged the Fellows of the Royal Society with "undermining the universities, destroying Protestantism, and introducing Popery"!

It would have been fortunate for Bruno, Galileo, and not a few of their colleagues, if the Inquisition and the Order of Jesus had taken the same view of the tendency of their researches. The discoveries of Sir Isaac Newton excited an outburst of hostility very similar to that which has in our own times greeted the theory of organic evolution. Then geology became the great bugbear; then followed the nebular hypothesis, till, as we have just hinted, anti-scientific jealousy concentrated itself upon the views of Darwin, Wallace, and their followers. If we read the controversial literature which has issued from the English press within the last half century, and note the motives therein imputed to men of science, we can scarcely doubt what would have been the fate of Buckland, Lyell, Sedgwick, Oken, Carus, Richard Owen, Darwin, had their enemies possessed as much power as malice. It must also be remembered that the practical applications of science and all attempts at its extension among the public have been met with a hostility no less pronounced. Franklin's lightning-conductor and Jenner's discovery of vaccination have been condemned from the pulpit as impious and blasphemous attempts to set aside the decrees of Heaven. A similar condemnation has since been pronounced against the use of anæsthetics, especially in midwifery.

The late Society for the Diffusion of Useful Knowledge, the London University, and the British Association, have each in turn passed through a tempest of abuse. The last-mentioned body, indeed, is still regularly "preached at" in every town which it visits.

In France the Chancellor, D'Aguesseau, refused a license to print Voltaire's "Letters on England," because the author therein expounded the discoveries of Newton, and disproved the vortex theory of Descartes. For adopting Locke's denial of innate ideas, a *lettre de cachet* was issued against Voltaire, and he was compelled to seek safety in flight. More recently the freedom of science seems to be recognized in France, Germany, and even in Italy. We must not, however, forget that the Roman Church has never formally retracted her claim to adjudicate upon scientific truth. An "Index" of proscribed books is still issued, and within the present century Pope Gregory, in an encyclical letter, characterized the freedom of the press as "deterrima illa ac nunquam satis execranda et detestabilis libertas artis literariæ."

In Britain the anti-scientific spirit still lingers more decidedly than elsewhere. Its chief lurking-places are sometimes said to be among the clergy and country gentlemen. We are not sure that this view is correct. Passing through a street in one of our northern manufacturing towns, the present writer once heard a demagogue addressing a crowd on something which he contended must be put down. That something was science! We are bound to say that his listeners gave every mark of sympathy and approval. The manner in which inventors have often been treated in different parts of England seems to show that such feelings are widely spread. The country which first wins over her working-classes to favor invention and to become themselves inventors will command the industrial supremacy of the world. America is fast attaining this object by her patent system, which enables even a poor man to secure his property in an invention. Our statesmen, Whig and Tory alike, can scarcely be restrained from laying additional difficulties in the way of patent right.

If we now, summing up, seek to know who have been the chief persecutors of science, we shall find the conventional answers too narrow. Many persons have laid the chief blame upon Roman Catholicism. It is very questionable, however, whether other churches, if they had been as widely spread, and had possessed as great civil power and authority, might not have equaled or even exceeded Rome. The religious bodies of Britain, established or dissenting, have certainly been unsurpassed in the virulence of their attacks upon geology and upon the new natural history. We strongly suspect that the Church of Rome will be the first religious body to admit that the doctrines of evolution and of the high antiquity of the human race are not necessarily opposed to the teachings of the Scriptures. So-called infidels of various grades of opinion have contended that Christianity in any and every form is the persecutor of science. We would submit, on the contrary, that discovery was persecuted in heathen and democratic Athens, where all the influence of Pericles barely sufficed to save his friend the philosopher Anaxagoras from a worse fate than banishment. Nay, we may even venture to predict that modern "free-thought" will before long appear as the adversary of Science, and, if sufficiently powerful, as her persecutor.

The jealousy of the industrial classes we have already glanced at.

Lest we should feel tempted to ridicule the suicidal folly of the working-classes in thus seeking to repress improvement, let us remember that Science is sometimes her own persecutor. Men who have gained a high official position in universities and academies are often actuated by a jealousy very similar to that which we have traced among ecclesiastics. They establish a certain scientific orthodoxy, based often to a great extent on mere conjecture and assertion, and seek to frown down and to silence the unknown outsider who calls in question one of their dogmas, or who discovers a truth which they have overlooked. That any region of research should be officially tabooed is a humiliating circumstance. The dread of truth, the jealousy of discovery, is not confined to the Holy Inquisition, and no disestablishment of churches, no secularization of schools and colleges, not even the suppression of every religion—were such a step possible—would put an end to its action.—*Journal of Science.*

THE PLEASURE OF VISUAL FORM.

By JAMES SULLY.

II.

HAVING thus determined what means of appreciating formal elements and relations are at the command of the eye, our next inquiry will naturally be, What modes of æsthetic intuition—in other words, what intellectual perceptions of pleasing and beautiful relations of form—are possible by help of these means? Fortunately, this side of the subject has been pretty fully investigated already, and I shall be able to pass it over with a very few words.

I here assume, what is agreed on by most writers, that beauty of form—so far as it is independent of sensuous pleasure on the one hand, and pleasures of association and suggestion on the other, is resolvable into the presence of a certain order among manifold details, which order is commonly spoken of as unity in variety. With respect, first of all, to the way in which the element of variety and contrast presents itself in visible form, a word or two will suffice. Direction and magnitude of lines, degree of change of direction, whether appearing as an angle or as a curve, each offers a field for the perception of difference and contrast. And each figure formed by a single arrangement of lines may, in its turn, become an element of variety in a larger scheme. It is worth noting that these elements of variety may be *indefinitely* present to the mind, as in the perception of all relations of distance and direction between points which are not connected by lines. The appreciation of superficial and solid, as distinguished from linear form, clearly involves a countless number of such less definite elements of visual perception.

The study of the various modes of securing a pleasing unity in visual form is a little more intricate. Speaking roughly, one may say that there are three distinguishable moments or aspects in this unity—namely, continuity of parts one with another; then common correlation with some one dominant element, which is usually the central one; and, finally, similarity and equality of parts. A word or two must suffice in illustrating each of these aspects:

1. We have found a reason for introducing continuity of lines into pleasing form in the nature of ocular movement. Over and above the feeling of smooth transition thus given, a continuous as opposed to a broken arrangement is at once felt to be a unity. The movement of the eye around a contour, to the point from which it set out, yields a peculiar feeling of gratification which may be called a sense of completeness.* The special æsthetic value of contour is seen in the custom of accentuating it in decorative designs by means of ornamental appendages. It is evident that this feeling for the æsthetic value of continuity in form will be developed by experience, which leads us to look on continuity of parts and contour as an essential factor in the unity of objects.

2. Another mode of unity in form closely related to continuity is common connection with one principal element of form, and more particularly with a dominant central feature. For the resting eye, as for the moving, the arrangement of parts about a center has a special value as supplying the most natural mode of percipient activity. Owing, indeed, to the structure of the retina, the center of an object or group of objects is naturally raised to a place of honor.† The eye is instinctively disposed to connect all parts of a design with some central element, and the recognition of such a common connection with a center gives to a design the artistic charm of unity. The most natural central element is, of course, a point, and there are many pleasing forms both in nature and in art which owe a part of their æsthetic value to the presence of such a connecting point. The circular and stellar or radiating forms, the scroll or volute, clearly have this central dominating factor. In many cases, however, the central element is a line or even some simple figure. Thus, all arrangements about an axis, as the forms of trees, flowers, and stems, and all like patterns, are pleasing. In decorative art, again, a central feature is frequently supplied in the shape of some small circle or rectilinear figure.

3. The third aspect of unity, similarity of parts, includes likeness of direction, equality of magnitudes, proportion, etc. All pleasing

* This is strictly analogous to the satisfaction which the ear derives from melodic movement, setting out from a given note (the tonic) and returning to the same.

† It is a distinguishing peculiarity of movements of the eye from the primary position outward, that they are attended by no rolling of the eye about the axis of vision. As a consequence of this, the eye, in tracing lines which radiate from the center of the field (exactly opposite to it), continues to receive the image of the line on the same retinal meridian or series of retinal points, so that at any two successive movements the images partly overlap. This fact speaks for the supreme importance of estimating direction and distance in relation to the center.

forms present similarities of direction, simple and compound, and the characteristic beauty of many forms, both in nature and in art, is traceable in part to the prominence of some one element of direction. Thus the various charms of the forms of cedar and birch among trees, and of the Romanesque and Gothic among architectural styles, are partly due to the predominance of some characteristic feature of form, as the horizontal or drooping line, the rounded or pointed arch.

The sense of equality enters into geometry much more prominently than into visual art; yet it is is not excluded from the latter, it only appears in a more disguised way. All equalities of magnitude among lines, surfaces, etc., are, to speak with Fechner, above the threshold of enjoyment, and the study of art in all its branches shows how considerable this enjoyment is. Among the equalities to which the æsthetically cultivated eye is specially susceptible are those in change of direction, whether angular or curvilinear. In all regular rectilinear figures equality of angle is appreciated as well as that of linear magnitude. The beauty of uniform curves and of undulating lines rests in part on a feeling for this factor of regular and equal change.

That relations of proportion enter into beautiful form is allowed by all. A technically trained eye may recognize, and perhaps enjoy, simple numerical ratios among magnitudes in lines, etc., but this factor does not appear to enter, in a conscious way at least, into ordinary æsthetic appreciation of form. We hardly experience any addition of enjoyment in learning that the ratio of the axes of a pleasing oval is 2 : 1. So far as conscious reflection can tell us, our enjoyment of proportion rests on a vague estimation of one magnitude in relation to another. But, though this relation is not numerically appreciated, it is very exactly estimated. Our enjoyment of the subtile relations of linear magnitude which enter into the beauty of a refined face shows how delicate this quantitative appreciation really is.

It is to be observed, further, that this fine sense of proportion among the various parts of a visible form includes a recognition more or less distinct of an equality between relations of magnitude. And it is this fact which brings the sense of proportion under the head of a feeling for similarity and equality. This is plain enough in the case of all imitative forms. The recognition of a face by means of a miniature portrait is really an example of a very fine perception of equalities of relation, for it rests on a distinct appreciation of the relative linear magnitudes and distances of the several features, and on a perception of the identity of these relations with all changes in absolute magnitude.

It is hardly less certain that the sense of proportion in art, when not thus based on a knowledge of the relations of natural objects, really implies a like recognition of identity of quantitative relations. The enjoyment of a due proportion between the breadth and length of a column, or among the numerous details of a Gothic church, springs from a recognition of the correspondence of the *perceived* relations with some *conceived* relations, which supply an ideal standard of proportion. This mental standard may repose either on a sense of utility or fitness of parts to a ruling end, on custom, or finally (in the case of the freer forms) on a vague feeling for the relative æsthetic importance of the several features as parts of a pleasing and well-balanced whole. If the eye has this delicate sense for quantitative relation, there is nothing intrinsically unreasonable in the doctrine put forth by Zeising, and partially countenanced by Fechner, that a special æsthetic value belongs to the division of a line into two unequal parts, of which the lesser shall be to the greater as this to the sum of the two or the whole. There is no numerical calculation involved here, and the only question to be asked is whether the eye really does prefer this peculiar division of parts, which Zeising calls "the golden section," and, if so, whether this is due to a sense of the quality of the ratios just named.

That the fact is as Zeising contends seems probable from Fechner's own investigations, in which he compares the different proportions of a large number of commonly recurring forms in ornaments, etc., where there is no apparent need of resorting to one mode of division rather than another. But does it follow that this customary preference involves a conscious comparison of the ratios here specified? In the case of a cruciform ornament, for instance, does the eye, however vaguely, sum together the vertical and horizontal magnitudes in the way supposed? May there not be a reason for choosing this particular division of a whole into parts, besides this hypothetical perception of an equality of ratios? I think there may be. It is noteworthy that, according to Zeising, the dimensions of the human figure illustrate this mode of proportion; and the question naturally arises whether this most frequent and most impressive object of contemplation may not have supplied a norm or ideal standard of proportion, to which we are apt to resort when there is no reason for selecting any other.

These three aspects or moments represent the most abstract principles of unity of form. In practice, these principles commonly combine and blend one with another. This may be seen by a reference to what is known as symmetrical arrangement.

A symmetrical division of parts aims at presenting a number of continuous features under certain aspects of contrast and similarity in relation to some central element. Each element of the design is balanced against some other element opposed to it in direction (that is, from the center), but resembling it in respect of magnitude and distance from the center. It thus supplies a large amount of the element of unity, and is indeed the most regular of all forms.

The most perfectly symmetrical figure is that which is so in respect of each pair of opposite sides or directions, as the rectangle, the polygon with even number of sides, the circle, etc. But such arrangements are apt to be too stiffly regular for art, which, needing abundance of freedom and variety, usually contents itself with symmetry in one direction, namely, bilateral symmetry. Why symmetry in an horizontal direction should please rather than in a vertical or any other direction will be explained further on.

It may still be objected that I am confounding art and science, and giving to unity and regularity an exaggerated æsthetic importance. This objection will, I think, be largely obviated by the observation, which I have hitherto postponed, that the uniting element is often present in an *ideal* manner only, suggested to the mind rather than directly presented. Thus the continuity of a form has sometimes to be appreciated by help of an ideal completion. For example, a crescent may please the eye because it is so easily expanded by the imagination into a whole circle. Much more frequently does the central element of a design need to be supplied by the mind of the spectator. The beauty of an undulating and of a spiral curve rests in part on a vague representation of the central axis, about which its seemingly free movements arrange themselves in so simple an order. In many symmetrical arrangements, too, as those of the human figure, the central element to which all relations are more or less consciously referred has to be put into the figure by the mind.

The value of such subjectively restored elements of unity is seen in a striking way in the fact that the feeling for order and unity may be satisfied when there is only an approximation to a regular arrangement. The eye, like the ear, can easily bear departures from rigid regularity, if only it is able in a rough and general way to group the details under relations of equality and symmetry. This it does in those freer forms of sculpture and painting which mark a high development of art. Provided this departure of form does not appear to the eye as an error, as a failure to reach perfect exactness—that is to say, provided it is seen to be intended and is felt to be justified—the fact of approximation yields an appreciable enjoyment. The visual imagination here supplements the visual sense, and sees a rightness where the latter alone would see but error.

It is easy to see, by help of this principle, that all the visual arts seek in some degree to satisfy the eye's feeling for form. In some arts, as painting, the element of form is no doubt a good deal subordinated to the exigencies of imitation, and of a wide picturesque variety of detail. Even in sculpture, perfect regularity of form is in the higher stages of art development sacrificed in favor of variety of treatment and natural ease. In truth, the progress of art is largely a progress in freedom of treatment, as we may see by comparing the rigid symmetry of Cimabue with the graceful ease of Raphael, or the stiff regularity of early Greek sculpture with the freedom of the later and better work. Yet, while the principles of form become less conspicuous, they are not wholly abandoned. A Madonna of Raphael may suggest the pyramidical form which an earlier altar-piece so naïvely forces on our attention. In other words, in the best periods of art, form only disguises itself, becomes more a matter of imaginative reconstruction, and appeals to a finer kind of æsthetic perception. One may add that every now and again the artist will distinctly aim at satisfying the eye's feeling for form by what may almost seem a childish device. Even a Turner does not disdain to please the eye by introducing into his pictures accidental repetitions of form in different objects.*

All good art thus does homage to the principle of form. One may even go further, and say that the characteristic effect of asymmetry, illustrated in many Japanese designs, is really due to a just feeling for form. Like discords and occasional suspensions of tone interval and equal time in music, such irregularities owe their piquancy to the very sense of a law that is broken, though not violently, but, so to speak, in childish freakishness.

In this brief analysis of the direct factor in pleasing visual form, I have regarded the immediate activity of the eye as something ultimate, only referring now and again to the effects of habit in facilitating certain kinds of motor activity. But modern psychological ideas will enable us to explain to some extent how the eye has come to be so constituted as to take pleasure in the kinds of activity just described. There is no room here for more than a brief elucidation of this aspect of the subject.

The doctrine of evolution leads us to view an organ of perception, together with its customary modes of action, as slowly determined by the action of the environment and the needs of practical life. A part of this operation goes on in the individual life, having as its result the selection of the habitual actions as the most easy and most agreeable. A part requires the life of the race for its carrying out, and has for its product a certain innate structure and disposition. The modes of agreeable visual perception illustrate these processes of adaptation to the conditions of practical life. Thus, as I have already hinted in passing, the eye's preference for the horizontal direction, for symmetrical movements of convergence, and so on, may possibly be explained as the result of habits determined by the greater utility of these particular movements. And it is probable, as Wundt suggests, that the innate peculiarities of the eye's mechanism which favor certain kinds of movement, as horizontal, and those from the center of the field, are themselves the result of long processes of racial adaptation.

What applies to the most natural and agreeable modes of ocular movement, applies also to the more pleasurable modes of the higher intellectual appreciation of form. The very feeling for unity of form in any shape is probably related to those deep wants of our existence

* Mr. Ruskin lays great stress on this effect, which he brings under his "Law of Repetition."

which have determined the structure of our intellectual organ to be what it is. And, in the case of the æsthetic value of the several modes of this unity, the action of the environment becomes apparent. Thus, for example, the natural instinct of the cultivated eye to look for a well-marked contour, as well as for a central element of repose, in a design, may be regarded as the result of ingrained habits, determined by the conditions of a distinct visual grasp and recognition of objects in every-day life. So the desire of the eye for proportion seems to be an outgrowth of a habit of attending to relative magnitude, a habit that is clearly connected with the paramount importance of identifying objects at different distances from the eye;* and, as I have already had occasion to observe, the popular preference for certain ratios of magnitude may be due to a habit of making the proportions of the human figure, that most impressive and carefully observed form, a special standard of measurement.

The æsthetic value of symmetry, and more especially bilateral symmetry, illustrates in a striking way this action of the environment and of habit in determining our most pleasurable modes of activity. Mr. Grant Allen has recently remarked on this fact ("Mind," Number XV.), but without any special reference to *bilateral* symmetry. Not only do most organic forms present such a bilateral symmetry, but the forms of inanimate nature, as mountain and valley, show this same relation. The very action of the physical forces determining the configuration of the earth's surface tends to produce a bilaterally symmetrical arrangement, as we may see by the simple experiment of throwing down a heap of pebbles or sand on the ground. Over and above this the ends of support, and the utilities of life in general, serve to give bilateral symmetry a high practical value. Most of the products of the useful arts, from architecture down to the art of constructing common utensils, possess this bilateral symmetry. This prevalence of the relation, in objects of daily perception, would serve to fix a habit of looking for symmetry as the normal form of things. In other words, bilateral symmetry would tend to become, to speak after Kant, a sort of *a priori* form of æsthetic intuition.

But this direct factor is, after all, only one feature of visual form, which, in concrete æsthetic perception, combines with other indirect or associated elements. Over and above the direct action of the environment, and of customary experience in producing an instinctive preference of the eye for some kinds of activity, there is an indirect action of experience in attaching to certain elements and arrangements

* I know a child that, when three years old, at once recognized the faces of several relatives by means of a photograph taken eight years before. The photograph was a *carte-de-visite* group, in which there were just a dozen full-length figures, as well as a good piece of background space. Such a power of appreciating form, shown at so early an age, suggests that there may be an innate disposition to recognize identity by means of equality of relative magnitude.

of form an æsthetic value by reason of associated feelings and ideas. This second great factor in visual form has received a fair amount of attention, and it does not call for more than a hasty reference here.

C. Associated Factor.—So far as forms are strictly non-imitative, and not determined by any needs of fitness to some recognized practical end, the associated factor must reside in certain comparatively abstract qualities. These are in the main resolvable into two classes—those æsthetic aspects which depend on association with touch and movement, and those which involve an idea of human skill.*

If tactual and muscular experiences (other than those of the ocular muscles) are organically embodied into our customary visual perceptions, we shall be prepared to find that the pleasurable side of visual form embraces elements drawn from this region. In truth, all the valued features of form may be said to involve such extraneous experiences. The superior importance of the vertical and horizontal directions, the specially restful character of the horizontal, and the aspiring aspect of the vertical, the voluptuous nature of the curve as opposed to the severity of the straight line, point to the deeper and fuller experiences of movement, muscular exertion, and repose, which we obtain apart from the eye. Even the value of bilateral symmetry for the eye may owe something to that well-marked rhythmic contrast of right and left, which the movements of the tactual organ yield to us. Again, it is easy to see that the various charm of distance, the wooing character of the remote and retiring, and the stimulating aspect of the near and prominent (reflected in a degree in the different effects of convex and concave surface), and the sublime suggestions of great height, all draw their material from experiences of the greater motor organs. So, too, our larger muscular experiences, with their new feeling of resistance and distinct sense of force, furnish elements to our appreciation of fragile grace appearing to ask for support, and of all stability of form. Lastly, the residue of tactile experience (alone or in combination with muscular sense) are traceable plainly enough in the charm of smooth and rounded surface, of that characteristic quality of sculpture which Mr. Ruskin has well called its "bossiness." †

The second class of æsthetically valuable suggestions in the visual perception of form are those of human skill. Man is a constructive animal, and his habits of construction lead him, as Mr. Grant Allen has observed, in the essay already spoken of, to view all forms in nature, as well as in art, in relation to the degree of skill needed to produce them.‡ Thus a perfectly straight line, even in nature, irre-

* A third class of such general and abstract associations might be constituted by the symbolic aspects or the moral and religious suggestions of form (as that of moral rectitude, infinity, etc.), but these are too vague and uncertain to require notice here.

† Herder calls sculpture the art of touch in contradistinction to painting, the art of sight.

‡ This idea of skill will, in the case of the useful arts, take the form of an intuition of a nice adjustment of means to ends, and so become a component element in the sense of fitness.

sistibly calls up a vague consciousness of artistic finish. The peculiar charm of all smaller and more delicate forms rests in part on this vague feeling of fine workmanship. So, too, all perfect regularity and symmetry satisfies this feeling for perfection of handicraft. And, on the other side, departures from regularity, when they suggest the idea of bad workmanship, are, as I have already remarked, distinctly unpleasant.

In addition to these widespread abstract associations with form, there are more circumscribed and concrete associations depending on a vague resemblance to some agreeable natural form. Of these associations the suggestions of human form constitute the most valuable æsthetic element. The supreme interest of the human presence makes us ever ready to see analogies to the human attitude and mode of movement in inanimate nature, and so we fall into the habit of attributing a quasi-human interest to the drooping plant, the stalwart tree rejoicing in its battles with the wind, and the venerable mountain looking down on our lower earth with an expression of Jovian calm. Art, when not distinctly imitative, owes something to these vague suggestions. Thus, we are disposed to transform supporting columns into caryatides before art itself transforms them for us. Next to the human figure, other of the more beautiful organic forms may furnish such associations to the eye. Thus, the Corinthian capital, and forms frequently found in ornamental design, please the eye in part through a vague feeling of their plant-like character.

The reader may perhaps expect us to assign the relative values to these various factors in agreeable form. But psychology is not yet a quantitative science; and, this being so, æsthetics must be content with enumerating the elements, without seeking to measure exactly their relative values. I have insisted on the presence of a direct sensuous element in visual form apart from the pleasures of light and shade. In daily experience we may not be aware of the pleasure which ocular movement in its real or ideal form is fitted to yield, just because our eye usually attends to these movements only as signs of important objective facts. But, when this significance is withdrawn, as in a decorative arabesque design, we may easily become aware of the pleasurable character of such movement. And it must be supposed that this element enters as a very appreciable factor into the whole delight which sculpture and architecture afford us. Even though not a considerable pleasure in isolation from other modes of enjoyment, it may contribute a valuable factor to such a compound æsthetic impression.*

But, though emphasizing these elementary motor experiences of the eye as a factor in agreeable form, I would not exaggerate their importance. It must be remembered that the experiences of touch and

* According to Fechner's principle of æsthetic support, "Vorschule der Æsthetik," p. 50, *et seq.*

extra-ocular movement are inseparably embodied with ocular feelings of movement in the eye's perception even of form elements, and the former are at least equally valuable with the latter. For the rest, I attach much value to the intellectual factor in the appreciation of form—that is, the coördination of numbers of these slightly pleasurable elements under agreeable relations of unity and proportion. Taking the factors just named as the *direct* factor, and contrasting them with the less directly associated elements as the *indirect* factor, I should say that the former decidedly outweighs the latter in what we call beauty of form. Every beautiful form will, I think, be found to owe its charm in the main either to the specially pleasurable character of its elements (ocular or tactual), or to the presence of a large number of distinct aspects of variety and unity. The former is the beauty of simple forms, the latter that of intricate forms.

HYSTERIA AND DEMONISM.*

A STUDY IN MORBID PSYCHOLOGY.

By CHARLES RICHET.

I.

PROBABLY very few persons who have been in Paris have visited the Salpêtrière. A home for old age, an asylum for the insane, are not tempting spectacles, and it pleases us rather than otherwise to be unmindful of the fact that within the great city of Paris is included another city of aged women and mad people, which contains nearly five thousand inhabitants. The Salpêtrière is designed primarily as an abode for infirm old women, and would afford materials for a very curious study of psychology in the observation of the feelings and passions of its inmates to any one desirous of analyzing the effects of age on human intelligence. This study may be attempted some day, but our present purpose is different. Among the insane who are confined in the Salpêtrière are patients who would formerly have been burned, whose disease would have passed for a crime three centuries ago. The study of the malady under which these unfortunates suffer, in its present and past aspects, affords a new and instructive chapter in the history of human thought.

In pursuing the present inquiry, we shall endeavor first to describe the psychological symptoms of hysteria. The knowledge of this disease has received a remarkable development under the careful investigations of the physicians of the Salpêtrière, and it may be that some of the facts they have discovered will interest persons who are not ac-

* Translated from the "Revue des Deux Mondes" by W. H. Larrabee.

quainted with medical science. We shall next inquire into the character of the demoniacal affections which were described in former centuries, and examine the strange succession of errors by which men were led to affirm that the devil took up his lodging in human bodies, and that it was necessary to burn him, to destroy those poor bodies which had become the receptacles and accomplices of malevolent spirits. Lastly, we shall review the history of the great trials for witchcraft in the sixteenth and seventeenth centuries. A chronological order would require that we should begin with the notice of demonism in the past, and close with the study of the corresponding affections of the present, but the reverse is the logical order. We shall follow with more interest the relation of the superstitions which led our ancestors astray, after we have become better acquainted with the facts that have been elucidated by contemporary investigators. In order to be able to judge error aright, we must first be acquainted with the truth.

An erroneous opinion prevails as to the causes and nature of hysteria. Romancers, particularly those who call themselves naturalists, have not neglected to propagate the doctrine that hysteria is an erotic disease. This is far from being exact. There is no relation of cause and effect between hysteria and celibacy; and we can speak of hysteria, study its causes, and describe its symptoms without infringing upon delicacy. It is a nervous disease, which has no more to do with sexual passion than other nervous diseases, and, notwithstanding the dread which it excites in half-instructed persons, we can say boldly that that dread is not justified. The facts that prove this point will appear shortly.

The asylum for the insane at the Salpêtrière is behind the buildings which are inhabited by the aged women. The hysterical patients are confined here. They are collected together in one part of the hospital, and have been for several years under the care of M. Professor Charcot. This learned physician, being desirous of applying to the nervous affections the exact methods which are employed in physiology, has established near the halls reserved for the patients a laboratory where precise studies of the most delicate phenomena of the pathology of the nervous system may be carried on. A photographic room is attached to the laboratory, in which exact representations of the principal phases of the attacks of hysteria, epilepsy, and somnambulism, have been obtained.* In this manner we have succeeded in securing minute descriptions of a class of psychological phenomena so strange and fantastic that, hardly more than three centuries ago, men saw in them the breath of the devil and of all the demons of hell.

Some persons may be surprised to learn that hysterical patients are

* These photographs, which are very instructive in the study of nervous diseases, form the publication of MM. Bourneville and Regnard, entitled "Iconographie photographique de la Salpêtrière."

confined in the Salpêtrière, for it has not been usual to regard hysteria as a grave disease necessitating or justifying seclusion. It is not always so grave. The disease manifests itself in every degree. Just as we may suffer a burn that is so superficial that we can hardly feel it, while there are other burns so deep and extended that they lead to death; just as there are light fevers and also fevers that are speedily mortal—so there are light hysteriæ, almost imperceptible, constituting a disposition of the organization rather than a disease, and besides them there are grave hysteriæ, so grave that they are confounded with insanity, with general paralysis, and with epilepsy. At the Salpêtrière, there are hardly any other hysterical cases than those of grave hysteria; as to light hysteria, it may be found everywhere. When the doctors speak of a nervous woman, they say an hysterical woman; and this language, though it may sound unpleasantly in a conversation or a romance, is not out of place in a psychological study, for what is commonly called nervousness in a young woman is simply hysteria.

I imagine that every one is more or less acquainted with the oddities of character exhibited by nervous women. All their feelings are carried to an extreme. The most trifling event is enough to provoke enthusiasm or despair in them. Nobody can cry so easily. It even seems to me that they control the fountain-key of tears, at least so as to make them flow, for to put a stop to them is another affair. To say that hysterical persons will cry for a small matter is saying too little, for they will cry for nothing; they will be all of a sudden possessed of an indefinable grief, an incomprehensible, vague sorrow, which it is not possible to resist. It is like a ball that rises from the chest to the throat, hinders respiration, and causes suffocation. They must retire, hide themselves in the most obscure corner, and there, where they are not seen or heard, sob for hours; then, suddenly, the fit of sorrow will cease and give place to a surprising gayety.

All that it has been customary to attribute to the nervous temperament of woman enters into the domain of hysteria. The appetite is capricious, fantastic: to-day, for example, everything displeases, and it is impossible to accept a particle of nourishment; to-morrow, all will be changed and nothing will suffice to appease the hunger. Generally, hysterical persons have a marked taste for vinegar and green fruits—a diet certainly not favorable to health. Such irregular and deficient alimentation impedes general nutrition and impoverishes the blood, and, by a kind of circular connection of disorders which is very common in pathology, the anæmia thus induced augments the hysteria which is the occasion of it; and young women suffering from it are more subject to hysteria than others.

As every one knows, the character of hysterical persons is very strange. We might say, borrowing an expression from the painters, that it is very picturesque, and presents points of view varied and always unforeseen. A young woman, for example, who yesterday had a charming disposition, was docile and amiable, is wholly changed to-day. She will not endure the least observation, is discontented with everything, has a bad look for everybody, breaks all rules, and is quite ungovernable. Her indocility is the more surprising, because it arises suddenly without cause, and disappears in the same manner. Self-love is always extravagantly developed. The most trifling pleasantry often becomes a cruel offense, to be borne with indignation, which tears enough can not be shed to protest against. Everything becomes the subject of a drama. Existence appears like a scene in a theatre. The regular, quiet life of every-day routine is transformed by the hysterical woman into a series of grave events, adapted to all sorts of dramatic developments. The hysterical sufferers continually play with an equal success at tragedy and comedy amid the flat scenes of reality. They can not comprehend simplicity in life, but make life a complication. Terror, jealousy, joy, anger, love, everything is exaggerated out of proportion with the just and measured feelings which are becoming.

Every human being, I believe, is moved by two opposing forces, sentiment and will. With the will we succeed (or think we succeed, which amounts to the same thing) in taming the feelings, in silencing the instinctive and passionate exuberance of the brute nature, we become masters of ourselves, *compos sui*, as the ancients said. We know that it is good to tell this, to conceal that, that there are noble sentiments and base passions, that we ought to obey the former and crush the latter. Hysterical persons do not know this, they do not comprehend what is meant by the power of ruling the passions. Passion leads them, and they suffer themselves to be carried where passion takes them. If the wind of anger or jealousy blows, they give themselves up, without opposition, to anger or jealousy; if it is the wind of charity or obedience, they are charitable or obedient. If the fancy to say what is impertinent or incongruous crosses their brain, the impertinent or incongruous saying is uttered. They are somewhat like persons who have taken hasheesh, and float off on the waves of fancy or enthusiasm.

We can never know how to depend on the feelings of an hysterical person. Any attempt to forecast them would be rash, and we may have equally good reasons to expect to find her well disposed or discontented. Her feelings will be likewise of the most fleeting character, and she will not imagine that it is necessary to establish transitions between laughing and tears, anger and satisfaction. Her bad humor will last while you turn an hour-glass, and she will behave like children who burst out in laughing while the tears they have just shed are still rolling down their cheeks.

Notwithstanding this mobility, this irresistible spontaneity, the victims of hysteria are wholly wanting in sincerity. They are all more or less liars; not so much, perhaps, that they are ready to tell selfish lies as that they indulge themselves in forging useless ones. They seem to have a love for lying, or rather for imposture. Nothing pleases them better than to lead those who question them into error; to relate stories that are absolutely false, which have not a shadow of probability; to give an account of all that they have not done and all that they have done, with an incredible luxury of details. These wanton lies are told boldly, bluntly, with a coolness that disconcerts. The physician who examines hysterical patients has always to bear in mind that they intend to deceive him, to hide the truth, and feign things that do not exist, as well as to disguise things that do exist.

Let us see now how hysteria differs from insanity. In insanity the intelligence is deeply affected, while hysteria is rather a form of disposition than a disease of the intellect. Hence the psychological interest of the hysterical condition. The apprehension is brilliant, the memory sure, the imagination lively. The defective side of the mind is revealed only by the impotency of the will to restrain passion. The will seems, in fact, to be the most delicate mechanism in the mental organization; and, when a poisonous substance enters the system to trouble the intellectual faculties, it always begins by suppressing the influence of the will over the passions.

Hysteria in its light form is of frequent occurrence. The causes that determine it ought then to be very common. One of the principal ones is heredity. If the father or mother has a nervous temperament, the daughter will probably be predisposed to hysteria. The sense of the word "heredity" as used here should be rightly understood. It is not necessary that the same form of affection shall appear in the parents and the children. A nervous derangement in the parents may be reproduced in the children under different aspects. For example, an epileptic father may have an idiotic son, an insane son, and an hysterical daughter. The law of hereditary liability is equally true when, instead of a nervous malady as grave as epilepsy or insanity, we have to do simply with a nervous temperament. Just as the color of the hair, the shape of the nose, and the voice are similar in parents and children, so the temperament is transmitted from one generation to another. The results of the medical observations of several centuries agree with the common opinion. In the times of witchcraft, the daughter of a witch—that is to say, of a person afflicted with hysteria—was inevitably regarded as a witch, and there was no need of seeking other motives for an accusation.

Other accessory causes supplement the preponderant influence of heredity. A girl, brought up with a certain degree of culture, who sees around her persons that were her companions in other days in a better situation than she has been able to reach, will become hysterical because fortune has not given her the enjoyments she craves. Dreams that have been dispelled, illusions that have vanished, hopes that have proved to be chimerical, afford motives almost sufficient to give rise to the affection. Thus hysteria is common in Paris and other large cities where girls of the lower and middle classes receive an education superior to their social condition. Such girls seldom find the ideal husband of whom they have dreamed. Marriage affords them no relief from the sordid difficulties that occur daily, and the narrow cares of the household afford an insufficient satisfaction to the vast aspirations of a disordered imagination. Misery, want, grief, etc., often cause the symptoms of hysteria to appear in girls and young women who have only a slight predisposition to it. To sum it all up, hysteria has a physiological cause—heredity ; and a social cause—the inferiority of the reality to the dream.

Light hysteria is not a true disease. It is one of the varieties of the female character. We might say that hysterical persons are women more than other women. They have lively and transient feelings, brilliant and variable fancies, and, withal, inability to bring their feelings and fancies under the rule of reason and judgment. The novelists have appreciated the advantage which they could derive from the study of this form of character, and have given us numerous pictures of attacks of hysteria, and of women who were subject to them. Their efforts have not always been fortunate, but occasionally they furnish exact descriptions which complement what we have just said respecting the psychical state of nervous women.

M. Octave Feuillet makes the husband of a woman who suffers from hysteria speak in a manner that, without pronouncing the word, projects the symptoms of the affection so plainly that there can be no mistake in the diagnosis. Thus : "That woman of the world," said M. de Marsan, " has suddenly borrowed from the prisoners a set of bitter, curt, desperate phrases, like those we may read on the walls of the cells. That woman of sense has all at once given herself up to the reading of the least reserved poets and novelists. . . . I inspire with terror from her elocution, formerly so sober, some insipid poetic perfume. At other times we might say she had fallen back into childhood, so nice and finical has become the turn of her conversation. She adds to it the movements of a little girl ; then all at once her language, just now modest almost to puerility, breaks out into the most indelicate flashes, into curiously improper expressions. She passes without transition from the style Rambouillet and the Byronic paraphrase to the coarse language of the fish-woman, and this without preparation, provocation, or excuse. At the same time, the woman, the wife, the mother, is transformed. The husband has assumed the proportions of a tyrant, and the children seem to have become a burden."

The last observation is true to the life. Nothing is more common than to see a nervous woman, till now tender to her husband and children, take a sudden disaffection or even a hatred against them. The aversion manifested in such cases may be provoked by the most futile causes, as, any insignificant external object, the shape of the beard, the watch-charms, a drawl in the tone of the voice, a habit of repeating the same word. It would be hard to invent deliberately such whimsical reasons as hysterical women are capable of imagining to explain the aversion they conceive for certain persons. The unfortunate person thus detested is most likely to be the husband.

M. A. France says of one of his heroines, that "she was pleasant, indolent, fastidious, subject to gushes of affection, and of quick sympathies. They had trouble in the refectory in making her eat anything but salads and bread with salt. She made a friend with whom she went on the days-out. This friend, who was rich, took Helen into the tapestried room, where she crunched *bonbons*. Helen lingered in this nest of goods. When she came out, all seemed dull, hard, repellent. She had lost courage ; she dreamed of having a blue chamber, and of reading romances in it lying in an easy-chair. Pains of the stomach came on and cast her down completely. . . . She gave up, indifferent to everything around her, dreaming of jewels, dresses, horses, sailing, and going into tears at the mere thought of her father."

MM. E. and J. de Goncourt have related the touching, sad story of poor Germinie Lacerteux. She was indeed a victim of hysteria ; of an untaught nature, passionate, ardent in devotion as in infamy ; of weak intelligence besides, the blind plaything of passions of which she was hardly conscious, and which moved her as the winds turn a vane. "Germinie had not a consciousness that could escape suffering by brutishness and that dense stupidity in which a woman may vegetate in simple inanity. A sickly sensitiveness, a head always busy, cherishing grief, inquietude, discontent with herself, a moral sense which seemed to rise in her again after each of her faults, all the gifts of delicacy, and the capacity of suffering were united in her to torture her." To feel, to think, to have no will, these are the three miseries with which the poor sufferers from hysteria have to struggle.

M. Albert Delpit has thus depicted the symptoms of hysteria in his "Mariage d'Odette": "She was seized with a fit of melancholy, to which succeeded violent spasms of crying and immoderate bursts of laughter ; sometimes she would shake with tremors from head to foot ; then she grew pale and felt an oppression at her chest. Her temper underwent an entire change. They had to give up taking her into society, its too free manners were so startling to her."

The most life-like hysterical character delineated by the novelists, the truest, the most passionate, is Madame de Bovary. Brought up in a convent, among girls richer than herself, she married a country doctor—a poor, weak youth, whose rusticity and poverty disheartened her. M. Flaubert has described her hysteria in a few lines with scientific precision and artistic distinctness: "Emma became hard to please, capricious ; she ordered dishes for herself and would not touch them ; one day she would drink nothing but pure milk, and the next coffee by the dozen cups. Sometimes she would persist in refusing to go out, then would think she was suffocating, would open the windows and put on a light dress. . . . She ceased to conceal her contempt for any thing or any person, and frequently assumed to express singular opinions—condemning what is approved, and approving wrong or immoral things. Must this misery last always? Will she never escape it? Yet she was worth as much as those who lived happily, and she execrated the injustice of God. She rested her head on the walls to cry. She envied those who led tumultuous existences, and longed for nights of masking and insolent pleasures with all the distractions she knew nothing of and which they could give. . . . She grew pale and had beatings of the heart. . . . On some days she would indulge in a feverish profusion of boasting. . . . To these indulgences succeeded immediately spells of torpor in which she would rest without speaking, without stirring. She bought a Gothic *prie-Dieu*, and spent fourteen francs in one month for lemons to clean her nails. She selected the handsomest of his scarfs from Lheureux's, tied it over her wrapper, and, having closed the shutters, lay in this garb upon the sofa with a book in her hand. She thought she would learn Italian, and bought dictionaries, a grammar, and white paper. She tried serious reading, history, philosophy. . . . She had fits when she could be readily pushed to extravagances. She insisted one day to her husband that she could drink half a glass of brandy, and, when Charles was foolish enough to challenge her to do it, she swallowed the brandy to the last drop."

We seem to be far away from the demoniacs, but we are not. We can observe all the transitions between light hysteria like that of Madame Bovary and grave hysteria like that of the patients in the Salpêtrière. All the symptoms of the light form exist likewise in the grave form, but they are stronger and more durable. We need not return to them. Other symptoms, special to grave hysteria and serving to characterize it, are anæsthesia, total or partial, convulsive attacks, and delirium.

BACTERIA AS DESTROYERS OF INSECTS.

By E. RAY LANKESTER, F. R. S.

"WHAT is the good of a knowledge of microscopic creatures? What is the good of prying into the anatomy of insects? It is all very well as an amusement, but serious persons can not be expected to assent to the devotion of endowments or state funds to such trivial purposes. Chemistry, geology, electricity, if you please, have their solid commercial value, but biology is an amusement for children and old gentlemen." Such is the opinion of many a "practical man," ignorant and short-sighted as the genus invariably proves itself.

Already the practical man may be told, in reply, that surgery is entirely reformed by our knowledge of the minuter fungi; that, by avoiding the access of bacteria to wounds, we avoid a large destruction of human life. Already we see our way to avoiding some deadly diseases caused by these same bacteria now that we know them to be the active cause of such disease. Already silk is cheaper in consequence of our knowledge of the bacteria of the silk-worm disease; already better beer is brewed and better yeast supplied to the baker in consequence of Pasteur's discovery of the bacterian diseases of the yeast-plant; already vinegar-making, cheese-making, butter-making, wine-making, and other such manufacturing trades are on the way to benefit by like knowledge. Potato-disease and coffee-disease have been traced to their causes and means suggested by biologists for dealing with the parasitic plants causing those diseases, whereby not thousands but millions of pounds sterling a year may be saved to the community.

Insect-pests which have depopulated whole provinces, such pests as the phylloxera and the Colorado beetle, are about to receive a check at the hands of the same class of scientific students. The application of knowledge of natural facts is in this case a very remarkable one; for it is actually proposed to make use of our recently acquired knowledge of diseases due to bacteria—not that we may arrest such diseases, but that we may promote them. Insect-pests are to be destroyed by poisoning them not with acrid mineral poisons which damage plants as well as the insects, but by encouraging the spread of the disease-producing bacteria which are known to be fatal to such insects. Professor Hagen, of Cambridge, Massachusetts, has called attention to the old practice of destroying greenhouse pests by the application of yeast. He conceives that this method may be applied to other insect-pests, such as phylloxera, Colorado beetle, cotton-worm, etc. He imagines that the yeast-fungus enters the body of the insect on which it is sprinkled, and there produces a growth which is fatal to the insect's life. It is a well-known fact that insects are very subject to fungoid diseases, and it is also ascertained that the application of yeast to the plants frequented by such insects favors their acquisition of such disease. Professor Elias Metschnikoff, the celebrated embryologist has, however, made some investigations on this subject, and given an explanation of the possible value of yeast application ("Zool. Anzeiger," No. 47), different and more satisfactory than that which Professor Hagen appears to adopt.

The general result of the most accurate investigations of the beer-yeast fungus (*Saccharomyces cerevisiæ*) is entirely opposed to the notion that it can enter an insect's body and produce a disease. Beer-yeast is beer-yeast and appears always (or within experimental limits) to remain so. On the other hand, De Bary has made known the life-history of some simple fungi which destroy insects, and from Pasteur, Cohn, and others we know of diseases due to those simplest of fungi, the bacteria, which produce the most deadly ravages among insects. Professor Metschnikoff has examined some of these minute parasitic fungi and cultivated them by passing them from one insect to another, and has experimentally proved their very deadly character to the insects exposed to infection. The "green muscardine" (*Isaria destructor*) is the name given by Metschnikoff to one of the minute fungi the effects of which he most successfully traced. Now, it is perfectly evident that if green muscardine spores could be produced in large quantity, or spores of similar disease-producing fungi, and applied to the ground and shrubs infested by insect-pests liable to harbor those fungi, we should have the best of all means for effecting the destruction of the insects, viz., a poison which once set at work would spontaneously multiply and spread its destroying agents around.

Accordingly, Professor Metschnikoff endeavored to cultivate the "green muscardine" apart from insects, so as to obtain its spores if possible in great quantity, in a liquid which might be applied to places attacked by injurious insects. He at last succeeded in effecting this cultivation by the use of beer-mash; in this decoction the "green muscardine" produced a rich mycelium and finally spores.

It is exceedingly probable that we have here the true explanation of the value of the application of yeast to plants, etc., affected by insect-pests. If there are a few spores only of such parasites as the "green muscardine" about, the fluids of the yeast will serve them for nourishment and so cause the muscardine to spread until it comes into contact with the insects. There is no reason to suppose that the beer-yeast plant itself is capable of generating a disease in any insects; at the same time we must remember that yeast as ordinarily used by the brewer is by no means pure: it contains in small quantities other minute fungi besides the *Saccharomyces cerevisiæ*, and it is quite possible that a given quantity of it, say a pint, *may*, if the brewery from which it came were not conducted on the most perfect system (such as that lately introduced by Pasteur), contain a few spores of such a disease-producing parasite as muscardine. A diseased insect once in a way falling into the mash-tub would sufficiently keep up the supply, and thus it is possible that yeast may carry infection to insect-pests and destroy them.

At the same time, Professor Metschnikoff's suggestion of a deliberate cultivation of an insect's disease-producing fungus, and the application of the cultivated fungus in quantity to places infested by these insects, is in the highest degree ingenious, and likely to give results the value of which will be estimated in thousands of pounds, and so do something to persuade "practical" men that all science is deserving of their respect and encouragement.—*Nature.*

SOME FACTS AND FICTIONS OF ZOÖLOGY.

By Dr. ANDREW WILSON.

WHEN the country swain, loitering along some lane, comes to a standstill to contemplate, with awe and wonder, the spectacle of a mass of the familiar "hair-eels" or "hair-worms" wriggling about in a pool, he plods on his way firmly convinced that, as he has been taught to believe, he has just witnessed the results of the transformation of some horse's hairs into living creatures. So familiar is this belief to people of professedly higher culture than the countryman, that the transformation just alluded to has to all, save a few thinking persons and zoölogists, become a matter of the most commonplace kind. When some quarrymen, engaged in splitting up the rocks, have succeeded in dislodging some huge mass of stone, there may sometimes be seen to hop from among the *débris* a lively toad or frog, which comes to be regarded by the excavators with feelings akin to those of superstitious wonder and amazement. The animal may or may not be captured; but the fact is duly chronicled in the local newspapers, and people wonder for a season over the phenomenon of a veritable Rip Van Winkle of a frog, which, to all appearance, has lived for "thousands of years in the solid rock." Nor do the hair-worm and the frog stand alone in respect of their marvelous origin. Popular zoölogy is full of such marvels. We find unicorns, mermaids, and mermen; geese developed from the shell-fish known as "barnacles"; we are told that crocodiles may weep, and that sirens can sing—in short, there is nothing so wonderful to be told of animals that people will not believe the tale; while, curiously enough, when they are told of veritable facts of animal life, heads begin to shake and doubts to be expressed, until the zoölogist despairs of educating people into distinguishing fact from fiction, and truth from theories and unsupported beliefs. The story told of the old lady, whose youthful acquaintance of seafaring habits entertained her with tales of the wonders he had seen, finds, after all, a close application in the world at large. The dame listened with delight, appreciation, and belief, to accounts of mountains of sugar and rivers of rum, and to tales of lands where gold and silver and precious stones were more than plentiful. But, when the narrator descended to tell of fishes that were able to raise themselves out of the water in flight, the old lady's credulity began to fancy itself imposed upon; for she indignantly repressed what she considered the lad's tendency to exaggeration, saying, "Sugar mountains may be, and rivers of rum may be, but fish that flee ne'er can be!" Many popular beliefs concerning animals partake of the character of the old lady's opinions regarding the real and the fabulous; and the circumstance tells powerfully in favor of the opinion that a knowledge of our surroundings in the world and an intelligent conception of animal and plant life should form part of the school-training of every boy and girl.

The tracing of myths and fables is a very interesting task, and it may, therefore, form a curious study, if we endeavor to investigate very briefly a few of the popular and erroneous beliefs regarding lower animals. The belief regarding the origin of the hair-worms is both widely spread and ancient. Shakespeare tells us that—

> " . . . . much is breeding
> Which, like the courser's hair, hath yet but life,
> And not a serpent's poison."

The hair-worms certainly present the appearance of long, delicate black hairs, which move about with great activity amid the mud of pools and ditches. These worms, in the early stages of their existence, inhabit the bodies of insects, and may be found coiled up within the grasshopper, which thus gives shelter to a guest exceeding many times the length of the body of its host. Sooner or later the hair-worm, or *Gordius*, as the naturalist terms it, leaves the body of the insect, and lays its eggs, which are fastened together in long strings, in water. From each egg a little creature armed with minute hooks is produced, and this young hair-worm burrows its way into the body of some insect, there to repeat the history of its parent. Such is the well-ascertained history of the hair-worm, excluding entirely the popular belief in its origin. There certainly does exist in science a theory known as that of "spontaneous generation," which, in ancient times, accounted for the production of insects and other animals by assuming that they were produced in some mysterious fashion out of lifeless matter. But not even the most ardent believer in the extreme modification of this theory, which holds a place in modern scientific belief, would venture to maintain the production of a hair-worm by the mysterious vivification of an inert substance such as a horse's hair.

The expression "crocodile's tears" has passed into common use, and it therefore may be worth while noting the probable origin of this myth. Shakespeare, with that wide extent of knowledge which enabled him to draw similes from every department of human thought, says that—

> " . . . . Gloster's show
> Beguiles him, as the mournful crocodile
> With sorrow snares relenting passengers."

The poet thus indicates the belief that not only do crocodiles shed tears, but that sympathizing passengers, turning to commiserate the reptile's woes, are seized and destroyed by the treacherous creatures. That quaint and credulous old author—the earliest writer of English prose—Sir John Maundeville, in his "Voiage," or account of his "Travaile," published about 1356—in which, by the way, there are to be found accounts of not a few wonderful things in the way of zoölogical curiosities—tells us that in a certain "contre and be all yonde, ben great plenty of Crokodilles, that is, a manner of a long Serpent as I have seyd before." He further remarks that "these Serpents slew men," and devoured them, weeping; and he tells us, too, that "whan thei eaten thei meven (move) the over jowe (upper jaw), and nought the nether (lower) jowe: and thei have no tonge (tongue)." Sir John thus states two popular beliefs of his time and of days prior to his age, namely, that crocodiles moved their upper jaws, and that a tongue was absent in these animals.

As regards the tears of the crocodiles, no foundation of fact exists for the belief *in* such sympathetic exhibitions. But a highly probable explanation may be given of the manner in which such a belief originated. These reptiles unquestionably emit very loud and singularly plaintive cries, compared by some travelers to the mournful howling of dogs. The earlier and credulous travelers would very naturally associate tears with these cries, and, once begun, the supposition would be readily propagated, for error and myth are ever plants of quick growth. The belief in the movement of the upper jaw rests on an apparent basis of fact. The lower jaw is joined to the skull very far back on the latter, and the mouth-opening thus comes to be singularly wide; while, when the mouth opens, the skull and upper jaw are apparently observed to move. This is not the case, however; the apparent movement arising from the manner in which the lower jaw and the skull are joined together. The belief in the absence of the tongue is even more readily explained. When the mouth is widely opened, no tongue is to be seen. This organ is not only present, but is, moreover, of large size; it is, however, firmly attached to the floor of the mouth, and is specially adapted, from its peculiar form and structure, to assist these animals in the capture and swallowing of their prey.

One of the most curious fables regarding animals which can well be mentioned is that respecting the so-called "bernicle" or "barnacle geese," which by the naturalists and educated persons of the middle ages were believed to be produced by those little crustaceans named "barnacles." With the "barnacles" every one must be familiar who has examined the floating drift-wood of the sea-beach, or who has seen ships docked in a seaport town. A barnacle is simply a kind of crab inclosed in a triangular shell, and attached by a fleshy stalk to fixed objects. If the barnacle is not familiar to readers, certain near relations of these animals must be well known, by sight at least, as among the most familiar denizens of our seacoasts. These latter are the "sea-acorns" or *Balani*, whose little conical shells we crush by hundreds as we walk over the rocks at low-water mark; while every wooden pile immersed in the sea becomes coated in a short time with a thick crust of these "sea-acorns." If we place one of these little animals, barnacle or acorn—the latter wanting the stalk of the former

—in its native waters, we shall observe a beautiful little series of feathery plumes to wave backward and forward, and ever and anon to be quickly withdrawn into the secure recesses of the shell. These organs are the modified feet of the animal, which not only serve for sweeping food-particles into the mouth, but act also as breathing-organs. We may, therefore, find it a curious study to inquire through what extraordinary transformation and confusion of ideas such an animal could be credited with giving origin to a veritable goose ; and the investigation of the subject will afford a singularly apt illustration of the ready manner in which the fable of one year or period becomes transmitted and transformed into the secure and firm belief of the next.

We may begin our investigation by inquiring into some of the opinions which were entertained on this subject and ventilated by certain old writers. Between 1154 and 1189 Giraldus Cambrensis, in a work entitled "Topographia Hiberniæ," written in Latin, remarks concerning "many birds which are called *Bernaca* : against nature, nature produces them in a most extraordinary way. They are like marsh geese, but somewhat smaller. They are produced from fir-timber tossed along the sea, and are at first like gum. Afterward they hang down by their beaks, as if from a sea-weed attached to the timber, surrounded by shells, in order to grow more freely." Giraldus is here evidently describing the barnacles themselves. He continues : "Having thus, in process of time, been clothed with a strong coat of feathers, they either fall into the water or fly freely away into the air. They derive their food and growth from the sap of the wood or the sea, by a secret and most wonderful process of alimentation. I have frequently, with my own eyes, seen more than a thousand of these small bodies of birds, hanging down on the seashore from one piece of timber, inclosed in shells, and already formed." Here, again, our author is speaking of the barnacles themselves, with which he naturally confuses the geese, since he presumes the crustaceans are simply geese in an undeveloped state. He further informs his readers that, owing to their presumably marine origin, "bishops and clergymen in some parts of Ireland do not scruple to dine off these birds at the time of fasting, because they are not flesh, nor born of flesh," although, for certain other and theological reasons, Giraldus disputes the legality of this practice of the Hibernian clerics.

In the year 1527 appeared "The Hystory and Croniclis of Scotland, with the cosmography and dyscription thairof, compilit be the noble Clerk Maister Hector Boece, Channon of Aberdene." Boece's "History" was written in Latin, the title we have just quoted being that of the English version of the work (1540), which title further sets forth that Boece's work was "Translatit laitly in our vulgar and commoun langage be Maister Johne Bellenden, Archedene of Murray, And Imprentit in Edinburgh, be me Thomas Davidson, prenter to the

Kyngis nobyll grace." In this learned work the author discredits the popular ideas regarding the origin of the geese. "Sum men belevis that thir clakis (geese) growis on treis be the nebbis (bills). Bot thair opinioun is vane. And becaus the nature and procreatioun of thir clakis is strange, we have maid na lytyll laboure and deligence to serche ye treuth and verite yairof, we have salit (sailed) throw ye seis quhare thir clakis ar bred, and I fynd be gret experience, that the nature of the seis is mair relevant caus of thair procreatioun than ony uthir thyng." According to Boece, then, "the nature of the seis" formed the chief element in the production of the geese, and our author proceeds to relate how "all treis (trees) that ar cassin in the seis be proces of tyme apperis first wormeetin (worm-eaten), and in the small boris and hollis (holes) thairof growis small worms." Our author no doubt here alludes to the ravages of the *Teredo*, or ship-worm, which burrows into timber, and with which the barnacles themselves are thus confused. Then he continues, the "wormis" first "schaw (show) thair heid and feit, and last of all thay schaw thair plumis and wyngis. Finaly, quhen thay ar cumyn to the just mesure and quantite of geis, thay fle in the aire as othir fowlis dois, as was notably provyn, in the yeir of God ane thousand iii hundred lxxxx, in sicht of mony pepyll, besyde the castell of Petslego." On the occasion referred to, Boece tells us that a great tree was cast on shore and was divided, by order of the "lard" of the ground, by means of a saw. Wonderful to relate, the tree was found not merely to be riddled with a "multitude of wormis," throwing themselves out of the holes of the tree, but some of the "wormis" had "baith heid, feit and wyngis," but, adds the author, "thay had no fedderis (feathers)."

Unquestionably either the scientific use of the imagination had operated in this instance in inducing the observers to believe that in this tree, riddled by the ship-worms, and possibly having barnacles attached to it, they beheld young geese; or Boece had construed the appearances described as those representing the embryo-stages of the barnacle-geese.

Boece further relates how a ship named the Christofir was brought to Leith, and was broken down because her timbers had grown old and failing. In these timbers were beheld the same "wormeetin" appearances, "all the hollis thairof" being "full of geis." Boece again most emphatically rejects the idea that the "geis" were produced from the wood of which the timbers were composed, and once more proclaims his belief that the "nature of the seis resolvit in geis" may be accepted as the true and final explanation of their origin. A certain "Maister Alexander Galloway" had apparently strolled with the historian along the seacoast, the former giving "his mynd with maist ernist besynes to serche the verite of this obscure and mysty dowtis." Lifting up a piece of tangle, they beheld the sea-weed to be hanging full of mussel-shells from the root to the branches. Maister Galloway opened one of the mussel-shells, and was "mair astonist than afore" to find no fish therein, but a perfectly-shaped "foule, smal and gret" as corresponded to the "quantity of the shell." And once again Boece draws the inference that the trees or wood on which the creatures are found have nothing to do with the origin of the birds; and that the fowls are begotten of the "occeane see, quhilk," concludes our author, "is the caus and production of mony wonderful thingis."

More than fifty years after the publication of Boece's "History," old Gerard of London, the famous "master in chirurgerie" of his day, gave an account of the barnacle-goose, and not only entered into minute particulars of its growth and origin, but illustrated its manner of production by means of the engraver's art of his day. Gerard's "Herball," published in 1597, thus contains, among much that is curious in medical lore, a very quaint piece of zoölogical history. He tells us that "in the north parts of Scotland, and the Ilands adjacent, called Orchades (Orkneys)," are found "certaine trees, whereon doe growe certaine shell fishes, of a white colour tending to russet; wherein are conteined little living creatures: which shels in time of maturitie doe open, and out of them grow those little living foules whom we call Barnakles, in the north of England Brant Geese, and in Lancashire tree Geese; but the other that do fall upon the land, perish, and come to nothing: thus much by the writings of others, and also from the mouths of people of those parts, which may," concludes Gerard, "very well accord with truth."

Not content with hearsay evidence, however, Gerard relates what his eyes saw and hands touched. He describes how on the coasts of a certain "small Ilande in Lancashire called Pile of Foulders" (probably Peel Island), the wreckage of ships is cast up by the waves, along with the trunks and branches "of old and rotten trees." On these wooden rejectamenta "a certaine spume or froth" grows, according to Gerard. This spume "in time breedeth unto certaine shels, in shape like those of the muskle, but sharper pointed, and of a whitish colour." This description, it may be remarked, clearly applies to the barnacles themselves. Gerard then continues to point out how, when the shell is perfectly formed, it "gapeth open, and the first thing that appeereth is the foresaid lace or string"—the substance described by Gerard as contained within the shell—"next come the legs of the Birde hanging out; and as it groweth greater, it openeth the shell by degrees, till at length it is all come foorth, and hangeth only by the bill; in short space after it commeth to full maturitie, and falleth into the sea, where it gathereth feathers, and groweth to a foule, bigger then a Mallard, and lesser than a Goose, having blacke legs and bill or beake, and feathers blacke and white . . . . which the people of Lancashire call by no other name then a tree Goose."

Accompanying this description is the engraving of the bernicle-tree, bearing its geese-progeny. From the open shells, in two cases, the little geese are seen protruding, while several of the fully-fledged fowls are disporting themselves in the sea below. Gerard's concluding piece of information, with its exordium, must not be omitted. "They spawne," says the wise apothecary, "as it were, in March or Aprill; the Geese are found in Maie or June, and come to fulnesse of feathers in the moneth after. And thus hauing, through God's assistance, discoursed somewhat at large of Grasses, Herbes, Shrubs, Trees, Mosses, and certaine excrescences of the earth, with other things moe incident to the Historie thereof, we conclude and end our present volume, with this woonder of England. For which God's name be euer honored and praised." It is to be remarked that Gerard's description of the goose-progeny of the barnacle-tree exactly corresponds with the appearance of the bird known to ornithologists as the "barnacle-goose," while there can be no doubt that, skilled as was this author in the natural-history lore of his day, there was no other feeling in his mind than that of firm belief in and pious wonder at the curious relations between the shells and their fowl-offspring. Gerard thus attributes the origin of the latter to the barnacles. He says nothing of the "wormeetin" holes and burrows so frequently mentioned by Boece, nor would he have agreed with the latter in crediting the "nature of the occeane see" with their production, save in so far as their barnacle-parents lived and existed in the waters of the ocean.

The last account of this curious fable which we may allude to in the present instance is that of Sir Robert Moray, who, in his work entitled "A Relation concerning Barnacles," published in the "Philosophical Transactions" of the Royal Society in 1677–'78, gives a succinct account of these crustaceans and their bird-progeny. Sir Robert is described as "lately one of His Majesties Council for the Kingdom of Scotland," and we may therefore justly assume his account to represent that of a cultured, observant person of his day and generation. The account begins by remarking that the "most ordinary trees" found in the western islands of Scotland "are Firr and Ash." "Being," continues Sir Robert, "in the Island of East (Uist), I saw lying upon the shore a cut of a large Firr-tree of about 2½ foot diameter, and 9 or 10 foot long; which had lain so long out of the water that it was very dry: And most of the shells that had formerly cover'd it, were worn or rubb'd off. Only on the parts that lay next the ground, there still hung multitudes of little Shells; having within them little Birds, perfectly shap'd, supposed to be Barnacles." Here again the description applies to the barnacles; the "little birds" they are described as containing being of course the bodies of the shell-fish.

"The Shells," continues the narrator, "hang at the Tree by a Neck longer than the Shell," this "neck" being represented by the stalk of the barnacle. The neck is described as being composed "of a kind of filmy substance, round, and hollow, and creassed, not unlike the Wind-pipe of a Chicken; spreading out broadest where it is fastened to the Tree, from which it seems to draw and convey the matter which serves for the growth and vegetation of the Shell and the little Bird within it." Sir Robert Moray therefore agrees, in respect of the manner of nourishment of the barnacles, with the opinion of Giraldus already quoted. The author goes on to describe the "Bird" found in every shell he opened; remarking that "there appeared nothing wanting as to the internal parts, for making up a perfect Sea-fowl: every little part appearing so distinctly, that the whole looked like a large Bird seen through a concave or diminishing Glass, colour and feature being everywhere so clear and neat." The "Bird" is most minutely described as to its bill, eyes, head, neck, breast, wings, tail, and feet, the feathers being "everywhere perfectly shaped, and blackish-coloured. All being dead and dry," says Sir Robert, "I did not look after the Internal parts of them," a statement decidedly inconsistent with his previous assertion as to the perfect condition of the "internal parts"; and he takes care to add, "Nor did I ever see any of the little Birds alive, nor met with anybody that did. Only some credible persons," he concludes, "have assured me they have seen some as big as their fist."

This last writer thus avers that he saw little birds within the shells he clearly enough describes as those of the barnacles. We must either credit Sir Robert with describing what he never saw, or with misconstruing what he did see. His description of the goose corresponds with that of the barnacle-goose, the reputed progeny of the shells; and it would, therefore, seem that this author, with the myth at hand, saw the barnacles only with the eyes of a credulous observer, and thus beheld, in the inside of each shell—if, indeed, his research actually extended thus far—the reproduction in miniature of a goose, with which, as a mature bird, he was well acquainted.

This historical ramble may fitly preface what we have to say regarding the probable origin of the myth. By what means could the barnacles become credited with the power of producing the well-known geese? Once started, the progress and growth of the myth are easily accounted for. The mere transmission of a fable from one generation or century to another is a simply explained circumstance, and one exemplified by the practices of our own times. The process of accretion and addition is also well illustrated in the perpetuation of fables; since the tale is certain to lose nothing in its historical journey, but, on the contrary, to receive additional elaboration with increasing age. Professor Max Müller, after discussing various theories of the origin of the barnacle-myth, declares in favor of the idea that confusion of language and alterations of names lie at the root of the error. The learned author of the "Science of Language" argues that the true barnacles were named, properly enough, *bernaculæ*, and lays stress on the fact that bernicle geese were first caught in Ireland. That country becomes *Hibernia* in Latin, and the Irish geese were accordingly named *Hibernicæ*, or *Hiberniculæ*. By the omission of the first syllable—no uncommon operation for words to undergo—we obtain the name *Bernicula* for the geese, this term being almost synonymous with the name *Bernacula* already applied, as we have seen, to the barnacles. Bernicle-geese and bernicle-shells, confused in name, thus became confused in nature; and, once started, the ordinary process of growth was sufficient to further intensify, and render more realistic, the story of the bernicle-tree and its wonderful progeny.

By way of a companion legend to that of the Barnacle-tree we may select the story of the "Lamb-tree" of Cathay, told by Sir John Maundeville, whose notes of travel regarding crocodiles' tears, and other points in the conformation of these reptiles, have already been referred to. Sir John, in that chapter of his work which treats "Of the Contries and Yles that ben bezonde the Lond of Cathay; and of the Frutes there," etc., relates that in Cathay "there growethe a manner of Fruyt, as thoughe it were Gowrdes: and whan thei ben rype, men kutten (cut) hem a to (them in two), and men fynden with inne a lytylle Best (beast), in Flessche in Bon and Blode (bone and blood) as though it were a lytylle Lomb (lamb) with outen wolle (without wool). And men eten both the Frut and the Best; and that," says Sir John, "is a gret marveylle. Of that fruit," he continues, "I have eten; alle thoughe it were wondirfulle"—this being added, no doubt, from an idea that there might possibly be some stay-at-home persons who would take Sir John's statement *cum grano salis*. "But that," adds this worthy "knyght of Ingelond," "I knowe wel that God is marveyllous in his Werkes." And not to be behind the inhabitants of Cathay in a tale of wonders, the knight related to these Easterns "als gret a marveylle to hem that is amonges us; and that was of the Bernakes. For I tolde hem hat in oure Countree weren Trees that beren a Fruyt, that becomen Briddes (birds) fleeynge: and tho that fellen in the Water lyven (live); and thei that fallen on the Erthe dyen anon: and thei ben right gode to mannes mete (man's meat). And here had thei als great marvayle," concludes Sir John, "that sum̃e of hem trowed it were an impossible thing to be." Probably the inhabitants of Cathay, knowing their own weakness as regards the lamb-tree, might possess a fellow feeling for their visitor's credulity, knowing well, from experience, the readiness with which a "gret marvayle" could be evolved and sustained.

Passing from the sphere of the mythical and marvelous as represented in mediæval times, we may shortly discuss a question which, of all others, may justly claim a place in the records of zoölogical curiosities—namely, the famous and oft-repeated story of the "Toad from the solid rock," as the country newspapers style the incident.

Regularly, year by year, and in company with the reports of the sea-serpent's reappearance, we may read of the discoveries of toads and frogs in situations and under circumstances suggestive of a singular vitality on the part of the amphibians, of more than usual credulity on the part of the hearers, or of a large share of inventive genius in the narrators of such tales. The question possesses for every one a certain degree of interest, evoked by the curious and strange features presented on the face of the tales. And it may therefore not only prove an interesting but also a useful study, if we endeavor to arrive at some just and logical conceptions of these wonderful narrations.

Instances of the discovery of toads and frogs in solid rocks need not be specially given; suffice it to say that these narratives are repeated year by year with little variation. A large block of stone or face of rock is detached from its site, and a toad or frog is seen hereafter to be hopping about in its usual lively manner. The conclusion to which the bystanders invariably come is, that the animal must have been contained within the rock, and that it was liberated by the dislodgment of the mass. Now, in many instances, cases of the appearance of toads during quarrying-operations have been found, on close examination, to present no evidence whatever that the appearance of the animals was due to the dislodgment of the stones. A frog or toad may be found hopping about among some recently formed *débris*, and the animal is at once seized upon and reported as having emerged from the rocks into the light of day. There is in such a case not the slightest ground for supposing any such thing; the animal may more reasonably be presumed to have hopped into the *débris* from its ordinary habitat. But, laying aside narratives of this kind, which lose their plausibility under a very commonplace scrutiny, there still exist cases, reported in an apparently exact and truthful manner, in which these animals have been alleged to appear from the inner crevices of rocks after the removal of large masses of the formations. We shall assume these latter tales to contain a plain, unvarnished statement of what was observed, and deal with the evidence they present on this footing.

One or two notable examples of such verified tales are related by Smellie, in his "Philosophy of Natural History." Thus, in the "Memoirs of the French Academy of Science" for 1719, a toad is described as having been found in the heart of an elm-tree; and another is stated to have been found in the heart of an old oak-tree, in 1731, near Nantz. The condition of the trees is not expressly stated, nor are we afforded any information regarding the appearance of the toads—particulars of considerable importance in view of the suggestions and explanations to be presently brought forward. Smellie himself, while inclined to be skeptical in regard to the truth or exactness of many of the tales told of the vitality of toads, yet regards the matter as affording food for reflection, since he remarks: "But I mean not to persuade, for I can not satisfy myself; all I intend is, to recommend to those gentlemen who may hereafter chance to see such rare phenomena, a strict examination of every circumstance that can throw light upon a subject so dark and mysterious; for the vulgar, ever inclined to render uncommon appearances still more marvelous, are not to be trusted."

This author strikes the key-note of the inquiry in his concluding words, and we shall find that the explanation of the matter really lies in the clear understanding of what are the probabilities, and what the actual details, of the cases presented for consideration. We may firstly, then, glance at a few of the peculiarities of the frogs and toads, regarded from a zoölogical point of view. As every one knows, these animals emerge from the egg in the form of little fish-like "tadpoles," provided with outside gills, which are soon replaced by inside gills, resembling those of fishes. The hind-legs are next developed, and the fore-limbs follow a little later; while, with the development of lungs, and the disappearance of the gills and tail, the animal leaves the water, and remains for the rest of its life an air-breathing, terrestrial animal. Then, secondly, in the adult frog or toad, the naturalist would point to the importance of the skin as not only supplementing but, in some cases, actually supplanting the work of the lungs as the breathing organ. Frogs and toads will live for months under water, and will survive the excision of the lungs for like periods; the skin in such cases serving as the breathing surface. A third point worthy of remembrance is included in the facts just related, and is implied in the information that these animals can exist for long periods without food, and with but a limited supply of air. We can understand this toleration on the part of these animals when we take into consideration their cold-blooded habits, which do not necessitate, and which are not accompanied by, the amount of vital activity which we are accustomed to note in higher animals. And, as a last feature in the purely scientific history of the frogs and toads, it may be remarked that these animals are known to live for long periods. One pet toad is mentioned by a Mr. Arscott as having attained, to his knowledge, the age of thirty-six years; and a greater age still might have been recorded of this specimen, but for the untoward treatment it sustained at the hands, or rather beak, of a tame raven. In all probability it may be safely assumed that, when the conditions of life are favorable, these creatures may attain a highly venerable age—regarding the lapse of time from a purely human and interested point of view.

We may now inquire whether or not the foregoing considerations may serve to throw any light upon the tales of the quarryman. The first point to which attention may be directed is that involved in the statement that the amphibian has been imprisoned in a *solid* rock. Much stress is usually laid on the fact that the rock was solid; this fact being held as implying the great age, not to say antiquity, of the rock and its supposed tenant. The impartial observer, after an examination of the evidence presented, will be inclined to doubt greatly the justification for inserting the adjective "solid"; for usually no evidence whatever is forthcoming as to the state of the rock prior to its removal. No previous examination of the rock is or can be made, from the circumstance that no interest can possibly attach to its condition until its removal reveals the apparent wonder it contained, in the shape of the live toad. And we rarely, if ever, find mention of any examination of the rock being made subsequently to the discovery. Hence, a first and grave objection may be taken to the validity of the supposition that the rock was solid, and it may be fairly urged that on this supposition the whole question turns and depends. For, if the rock can not be proved to have been impermeable to and barred against the entrance of living creatures, the objector may proceed to show the possibility of the toad having gained admission, under certain notable circumstances, to its prison-house.

The frog or toad in its young state, and having just entered upon its terrestrial life, is a small creature, which could, with the utmost ease, wriggle into crevices and crannies of a size which would almost preclude such apertures being noticed at all. Gaining access to a roomier crevice or nook within, and finding there a due supply of air, along with a dietary consisting chiefly of insects, the animal would grow with tolerable rapidity, and would increase to such an extent that egress through its aperture of entrance would become an impossibility. Next, let us suppose that the toleration of the toad's system to starvation and a limited supply of air is taken into account, together with the fact that these creatures will hibernate during each winter, and thus economize, as it were, their vital activity and strength; and after the animal has thus existed for a year or two—no doubt under singularly hard conditions—let us imagine that the rock is split up by the wedge and lever of the excavator; we can then readily enough account for the apparently inexplicable story of "the toad in the rock." "There is the toad and here is the solid rock," say the gossips. "There is an animal which has singular powers of sustaining life under untoward conditions, and which, in its young state, could have gained admittance to the rock through a mere crevice," says the naturalist in reply. Doubtless, the great army of the unconvinced may still believe in the tale as told them, for the weighing of evidence and the placing *pros* and *cons* in fair contrast are not tasks of congenial or wonted kind in the ordinary run of life. Some people there will be who will believe in the original solid rock and its toad, despite the assertion of the geologist that the earliest fossils of toads appear in almost the last-formed rocks, and that a live toad in rocks of very ancient age—presuming, according to the popular belief, that the animal was inclosed when the rock was formed—would be as great an anomaly and wonder as the mention as an historical fact of an express-train or the telegraph in the days of the patriarchs. The reasonable mind, however, will ponder and consider each feature of the case, and will rather prefer to countenance a supposition based on ordinary experience than an explanation brought ready-made from the domain of the miraculous. While not the least noteworthy feature of these cases is that included in the remark of Smellie respecting the tendency of uneducated and superstitious persons to magnify what is uncommon, and in his sage conclusion that, as a rule, such persons in the matter of their relations "are not to be trusted."

But it must also be noted that we possess valuable evidence of a positive and direct kind bearing on the duration of life in toads under adverse circumstances; and, as this evidence tells most powerfully against the supposition that the existence of those creatures can be indefinitely prolonged, it forms of itself a veritable court of appeal in the cases under discussion. The late Dr. Buckland, curious to learn the exact extent of the vitality of the toad, caused, in the year 1825, two large blocks of stone to be prepared. One of the blocks was taken from the oölite limestone, and in this first stone twelve cells were excavated. Each cell was one foot deep and five inches in diameter. The mouth of each cell was grooved so as to admit of two covers being placed over the aperture; the first or lower cover being of glass, and the upper one of slate. Both covers were so adapted that they could be firmly luted down with clay or putty; the object of this double protection being that the slate cover could be raised so as to inspect the contained object through the closed glass cover without admitting air. In the second or sandstone block a series of twelve cells was also excavated; these latter cells being, however, of smaller size than those of the limestone block, each cell being only six inches in depth by five inches in diameter. These cells were likewise fitted with double covers.

On November 26, 1825, a live toad—kept for some time previously to insure its being healthy—was placed in each of the twenty-four cells. The largest specimen weiged 1,185 grains, and the smallest 115 grains. The stones and the immured toads were buried on the day mentioned, three feet deep, in Dr. Buckland's garden. There they lay until December 10, 1826, when they were disinterred and their tenants examined. All the toads in the smaller cells of the sandstone block were dead, and from the progress of decomposition it was inferred that they had succumbed long before the date of disinterment. The majority of the toads in the limestone block were alive, and, curiously enough, one or two had actualy increased in weight. Thus, No. 5, which at the commencement of its captivity had weiged 1,185 grains, had increased to 1,265 grains; but the glass cover of No. 5's cell was found to be cracked. Insects and air must, therefore, have obtained admittance and have afforded nourishment to the imprisoned toad; this supposition being rendered the more likely by the discovery that in one of the cells, the covers of which were also cracked and the tenant of which was dead, numerous insects were found. No. 9, weighing originally 988 grains, had increased during its incarceration to 1,116 grains; but No. 1, which in the year 1825 had weighed 924 grains, was found in December, 1826, to have decreased to 698 grains; and No. 11, originally weighing 936 grains, had likewise disagreed with the imprisonment, weighing only 652 grains when examined in 1826.

At the period when the blocks of stone were thus prepared, four toads were pinned up in holes five inches deep and three inches in diameter, cut in the stem of an apple-tree; the holes being firmly plugged with tightly fitting wooden plugs. These four toads were found to be dead when examined along with the others in 1826; and of four others inclosed in basins made of plaster-of-Paris, and which were also buried in Dr. Buckland's garden, two were found to be dead at the end of the year, their comrades being alive, but looking starved and meager. The toads which were found alive in the limestone block in December, 1826, were again immured and buried, but were found to be dead, without leaving a single survivor, at the end of the second year of their imprisonment.

These experiments may fairly be said to prove two points. They firstly show that even under circumstances of a favorable kind when compared with the condition popularly believed in—namely, that of being inclosed in a *solid* rock—the limit of the toad's life may be assumed to be within two years; this period being no doubt capable of being extended when the animal possesses a slight advantage, exemplified by the admission of air and insect-food. And, secondly, we may argue that these experiments show that toads when rigorously treated, like other animals, become starved and meager, and by no means resemble the lively, well-fed animals reported as having emerged from an imprisonment extending, in popular estimation, through periods of inconceivable duration. These tales are, in short, as devoid of actual foundation as are the modern beliefs in the venomous properties of the toad, or the ancient beliefs in the occult and mystic powers of various parts of its frame when used in incantations. Shakespeare, while attributing to the toad venomous qualities, has yet immortalized it in his famous simile, by crediting it with the possession of a "precious jewel." But even in the latter case the animal gets but scant justice; for science strips it of its poetical reputation, and in this, as in other respects, shows it, despite fable and myth, to be an interesting but commonplace member of the animal series.—*Gentleman's Magazine.*

THE ELECTRICAL POLYSCOPE.

THE electrical polyscope is a simple and ingenious apparatus for giving light in the cavities of the human body, the invention of M. Trouvé, who has distinguished himself by the contrivance of several other instruments useful to physicians and involving curious applications of electricity. It consists of an energetic and constant battery, of a reservoir or secondary battery, and of parabolic reflectors adapted to the different uses to which it may be applied, which are furnished with additional mirrors or used without them. A minute platinum thread, connected with the conducting wires of the battery, is placed in the middle of each reflector. When the battery is put in action, the wire becomes incandescent. A special rheostat is provided to regulate the flow of the electricity, which plays a part similar to that of the faucet of a water-reservoir, and controls the flow of the fluid with such exactness as to permit the finest threads of platinum

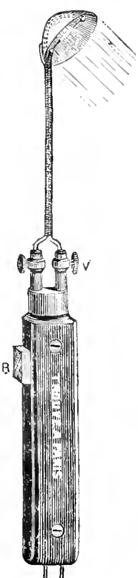


Fig. 1.

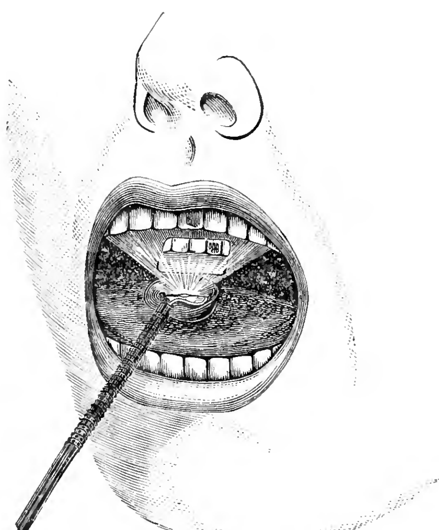


Fig. 2.

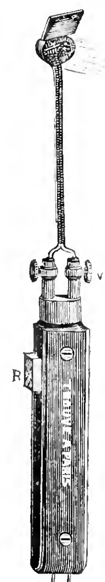
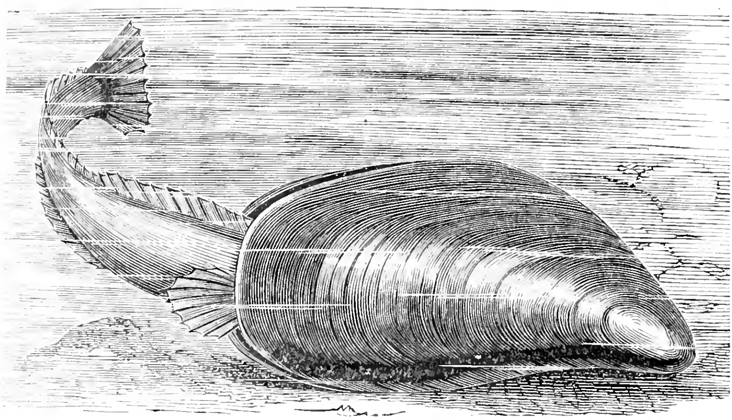


Fig. 3.

to approach the point of fusion without passing it. The melting-point of the wires used having been determined in the beginning, can always afterward be avoided without trouble. A galvanometer with two circuits, in which the electro-motive force of the reservoir and that of the battery are in opposition, enables the operator to observe the condition of the apparatus at every moment. Figs. 1 and 3 represent two of the reflectors. That shown in Fig. 1 is used to light up the mouth, and is of such power as to render the teeth transparent, and make them show every detail of their condition. Placed on the extremity of a probe inserted in the œsophagus, it makes it possible to observe the condition of the stomach. Fig. 3 shows the reflector with mirrors for use in laryngoscopy and rhinoscopy. This adaptation of the instrument may be used by dentists to show the back part of the teeth, without compelling the patient to assume a disagreeable position, as in Fig. 2. The polyscopes are superior to every other device for introducing light to all parts of the human body. With them the source of light may be placed at as minute a distance as is desired from the part to be examined without inconvenience to the operator. With a slight modification the polyscope may be employed as the instrument for performing the very different operation of cauterization. It is of service in other fields than those of medicine and surgery. Captain Manceron, at St. Thomas of Aquinas, has used it to examine the interior of shells and cannon. It is employed likewise in powder magazines, and is a similar apparatus to that used by divers and gatherers of oysters, corals, and pearls, to light up the bottom of the sea.

CAPTURE AMONG THE MOLLUSKS.

MR. STEPHEN CLOGG has kindly forwarded us a box containing a shanny and a mussel, which he describes as having been taken in the harbor at Looe, Cornwall, in exactly the position represented in the accompanying illustration. The shanny and mussel, our correspondent writes, were taken by a fisherman who was gathering mussels for bait at Looe. Mussels are found in great numbers at the bottom of the harbor there, and the fishermen use a long-handled, four-pronged fork for catching them. A boat is moored over the spot on which the mussels are to be found, and the fork is employed to bring them from below into the boat. In the case in question, our correspondent assures us the shanny and mussel were brought up as shown in our illustration. The fish was alive when taken, and its head firmly fixed in the mussel. This certainly may be considered a curious capture, and from the evidence it may be fairly assumed that the shanny, seeing a tempting mussel with its mouth open, was induced to pop his head in—an operation which Master Mussel doubtless resented by immediately closing its valves, retaining the fish in its deadly grasp. A case in point of fish being taken in this way is mentioned by Couch, in which Lacépède records an instance where, as he (Lacépède) supposes, a shanny had made an attempt to feed on an oyster that lay with its valves open, in consequence of which it became shut up a prisoner by the closing of the shell. In this case, however, the shanny was more fortunate than the one taken the other day, for it is stated that in this condition of confinement the fish had continued so long that the oyster had been dredged and carried to a considerable



SHANNY CAUGHT BY MUSSEL.

distance. Upon opening it, the captive was again set free alive, and without injury. Shanny are very retentive of life, and would be found nice additions to salt-water aquaria.

In our columns some years ago was recorded an even more extraordinary capture than either of the above, by Mr. Frank Buckland. As doubtless many of our readers have not seen it, we reproduce Mr. Buckland's remarks and the illustration which appeared at the time:

"Some time since, when examining the famous oyster-beds at Helston, near Falmouth, Mr. Fred Hill, of Helston, was kind enough to accompany me and my friend Mr. Howard Fox, of Falmouth, in our expedition. Mr. Hill mentioned to me at the time that he had a curious specimen of a bird that had been caught by an oyster. The bird and oyster had been mounted in a case by Mr. Vingor, of Penzance. I have received from Mr. Hill a photograph of the above event, which I have since had engraved as above. The history is, that a woman who sells oysters went one morning to the Helford River and found the bird—a common rail—dead, with its beak held quite firmly by the oyster, which was still alive.

"The bird in all probability was wandering along the foreshore looking for his dinner, and Mr. Oyster—possibly left longer by the tide than usual—was opening his shells waiting the incoming water. The hungry rail, seeing something that looked like a white and dainty bit of food, pecked at the body of the oyster, and probably pricked him sharply with his beak. The oyster then snapped his shells together as quick as a rat-trap, and the poor bird instantly became a prisoner to die (or possibly get drowned as the tide rose) in his prison.

"A story is told of a nigger in America who was caught in a somewhat similar manner. The nigger put his tongue between the shells

RAIL CAUGHT BY OYSTER.

of a half-opened oyster to suck out the juice, and the oyster caught him tightly by the tongue. Sambo, when released, was chaffed about it. 'Why, the oyster could not have hurt you,' said his friend; 'he has no teeth.' 'No,' said Sambo, 'he 'ave no teeth, but by Gorry he have dam hard gums!'"

In the late report on "The Sea-Fisheries" Mr. Buckland published a large mass of information in regard to mussels. In the course of this he says:

"Mussels have a great number of enemies, the chief of which are five-fingers, or star-fish, and whelk-tingles. It is most interesting to watch the five-fingers eating the mussels. The whelk-tingles, or white buckies, as they are called at Montrose, will clear off in a few hours a large acreage of mussels. The proprietors, therefore, employ women and children to pick them off at low tide. Not only are mussels largely used as bait, but they are a favorite food of the poor, and are sold in large quantities in the streets of the large towns of England—Manchester, Liverpool, Birmingham, etc. They are, in fact, 'the poor man's oyster.' So much, indeed, are mussels used as food, that a proposition was more than once seriously made to us by the fishermen that it should be illegal to use mussels for human food. As regards their value as food, I have made the following calculation : There are on the average thirty-nine mussels to the pound, equal to 87,360 mussels in a ton. These cost first hand £1 5*s.* per ton ; the cost to the retailers is £3 6*s.* 8*d.* per ton. In March, 1876, a large number of crows were observed eating mussels (query, fresh-water) in the Norfolk Broads. There are large quantities of mussels in many of the broads and rivers, especially in South Walsham Broad, and also, I believe, in Hoveton Broad, Ormesby Broad, and Fritton Water. At the present time I believe no use whatever is made of them ; it is as well to see if these mussels can not be cultivated and used for bait."—*Land and Water.*

HOW INSECTS DIRECT THEIR FLIGHT.*

By M. J. DE BELLESME.

THE works of M. Marey have nicely determined the difference between the manner in which birds and insects fly. The bird can change at will the angle of vibration of his wings, and therefore these organs serve to steer his flight. The insect is deprived of this power, because the angle of vibration, as a rule, is invariable in each species, the flying-muscles not being in the wings, but in that part of the thorax which supports the wings.

Knowing these facts, I concluded that if the wing of the insect be merely a motor apparatus, the steering function must be sought for elsewhere ; and, from numerous experiments made upon insects of every order, I am convinced that the steering power depends upon the position of the head and thorax, this, in its turn, depending upon the respective positions of the center of gravity and the axis of suspension (*l'axe de sustention*). Both these elements are sometimes movable, but more often it is the center of gravity which changes.

* From a paper read before the Paris Academy of Sciences, and published in "Comptes Rendus." Translated by M. Howland.

There are a few insects in which the motor and steering functions are united, the flying-muscles being attached to the wings. These insects fly gracefully, like birds; still, the abdomen is very long, flexible, and greatly augments the ease and variety of motion; this is specially apparent in the *Agrions*—the dragon-fly, for example. It is probable that the *Lepidoptera* (butterflies, moths) should be ranged in the same category, for the movement of their wings is something like that of birds; the anatomy of their thoracic muscles, however, has not yet been completely analyzed.

In the *Hymenoptera* (bees, wasps, etc.) are found the first indications of separate functions of translation and direction. The wings, having acquired a very perfect automatism by which the axis of suspension has become permanently fixed, are solely devoted to the function of movement. The abdomen has become pediculated and exceedingly mobile. As it bends up or straightens out, the center of gravity is carried forward or backward. The *Cynips* (gall-flies, etc.) and *Ichneumonides* (insects that prey upon the eggs of other insects) offer extreme examples. If the abdomen be prevented from moving, the animal can still fly, but can not direct its course. Moreover, the posterior legs of these insects are long, as in the *Polistes* and *Megachiles*, and this also aids in displacing the center of gravity.

In the *Orthoptera* (crickets, grasshoppers, etc.) the abdomen is but slightly movable, and the steering power is almost wholly in the hind-feet; but, as these are already differentiated for an equally important function, that of jumping, they lend themselves with a bad grace to the former function, and so the hopping insects fly very badly.

Thus far we have seen the two pairs of wings devoted to the motor function. We come now to a class of insects in which the functional adaptation is not secured through organs performing other functions and lending themselves to extra duties, but where the adaptation is secured through its own proper organs—one of the pairs of wings, indeed, which, diverted from the motor function, has become a steering apparatus.

In the group of *Coleopters* (beetles), only one pair of wings, the posterior, serve to sustain the insect; the surface of support, therefore, is considerably diminished, and the flight is heavy or clumsy. But this disadvantage is compensated by the greater extent of surface afforded by the non-modified pair. This surface, indeed, is so great that the insect is obliged to fold it up during rest. The abdomen of the *Coleoptera* is stiffly fixed to the thorax, and consequently is but slightly movable; but this quality is unnecessary, since a special organ, the elytrum (wing-case), has power to displace the center of gravity. Raised up over the thorax during flight, the elytrum forms a little swaying mass above the center of gravity, and the slightest motion of this mass affects the balance of the insect. Remove the wing-cases, and the insect still flies, but has no power to direct its motion, which is upward, downward, or horizontal, according to the position of the center of gravity at the moment of the experiment. M. Plateau has clearly demonstrated that the normal position of this point varies with each species.

One very small group, the *Cetoniadæ*, fly with the wing-cases down—an interesting fact, for in this instance they act upon the axis of suspension, and effect a step toward the state of complete differentiation which we find in the following group.

In the *Diptera* (mosquitoes, flies, etc.) the steering faculty reaches its highest development. The second pair of wings is transformed into organs having the special function of steering, the balancers or poisers; and these insects have accordingly a remarkable perfection of movement. A single pair of wings does all the flying, and, as they are not large, the diminution of the supporting surface is compensated by greater rapidity of vibration. I have proved by experiment that the balancers act by displacing the axis of suspension. Suppress the balancers, and the flight becomes fatally downward, because the normal and invariable position of the center of gravity is in front of the axis of suspension; the animal, therefore, can not modify his movement in any way, the abdomen being but slightly movable, and the balancers cut off. If, now, we come to his relief and attach a tiny weight to his abdomen, just sufficient to carry the center of gravity back to its normal place, we restore to the insect the power to perform all his aërial evolutions.

SKETCH OF JAMES CLERK MAXWELL.

AMONG the present generation of English physicists none have attained to greater eminence, or have made more valuable additions to this department of science, than the late Professor Maxwell. The splendid promise that his accomplished work gave of future work makes his death, at the early age of forty-nine, at the height of his powers, an irreparable loss to science. An accomplished mathematician, an unexcelled experimenter, he was peculiarly fitted to carry on those delicate researches in the domain of molecular physics by which he made it his own, and in which he was without a rival. Possessed of a vivid imagination, he had that power of holding it well under control, and making it subservient to the conditions of scientific investigation, that belongs only to the highest types of mind, and which is essential to the best and most valuable work in science. Though possessed of the power of direct and lucid exposition, he was never what is termed a popular lecturer. The subjects he considered, and his condensed form of presenting them, debarred any, save those whose knowledge was sufficiently extended, from following him in his exposition. But, by the students who enjoyed the privilege of attending his lectures, he was regarded as a teacher of the greatest value, though at times somewhat difficult to follow. Of a kindly and genial disposition, Professor Maxwell secured the affectionate regard of those with whom he came in contact, and to many his death comes as the double loss of a companion in work and of a valued friend.

Professor Maxwell was born in the year 1831, being the only son of John Clerk Maxwell, Esq., of Middlebie, Dumfriesshire, Scotland. When eight years old his mother died, and his father thereafter lived a retired life on his estate, devoting himself to the education of his son and the care of his property. He received his early education at the Edinburgh Academy, and after leaving there entered the University of Edinburgh. In 1850 he went to Cambridge, from which he was graduated in 1854, as second wrangler. In the following year he became a Fellow of Trinity College, and a year later accepted the position of Professor of Natural Philosophy in Marischal College, Aberdeen, which he held until the fusion of this and King's College. He succeeded Professor Goodeve as Professor of Natural Philosophy and Astronomy in King's College in 1860, and remained there until the death of his father in 1865, when he retired to his estate in Scotland. None of these positions had been entirely in accordance with his tastes, or such as to give full scope to his abilities. Such an opportunity as in every way suited him was opened to him in 1871, by the invitation of the University of Cambridge to the newly created chair of Experimental Physics, which he held until the time of his death. Shortly after his acceptance of the position, the Cavendish Laboratory, with a complete equipment of apparatus, was presented to the university by the Duke of Devonshire, and it is due to the superintendence of Professor Maxwell that this laboratory is so excellently adapted to its purpose.

During the winter of 1878 and 1879 Professor Maxwell's health failed him, and in the spring he betook himself to Scotland in the hope of regaining it. He was not improved by his trip, and he therefore returned to Cambridge, where under the treatment of Dr. Paget he grew better, and hopes were entertained of his recovery. The improvement, however, was not lasting, and he rapidly grew weaker until his death, on the 5th of November last.

Professor Maxwell commenced original work at an early age, and his contributions to the "Transactions" of societies and scientific periodicals have been voluminous. A mathematical paper "On the Description of Oval Curves, and those having a Plurality of Foci," was submitted by him to the Royal Society of Edinburgh, through Professor Forbes, before he was fifteen. While at the University of Edinburgh he contributed two elaborate papers to the Edinburgh Royal Society, one on the "Theory of Rolling Curves," and the other on the "Equilibrium of Elastic Solids."

During his college course in Cambridge he developed the germs of his future important work on electricity and magnetism, in a paper on "Faraday's Lines of Force," and five other papers on the same subject were contributed by him to the "Philosophical Magazine" during 1861 and 1862. Only a few months after obtaining his Cambridge degree in 1854, he contributed to the Cambridge Philosophical Society a remarkable paper on the "Transformation of Surfaces by Bending." In 1857 his paper on the "Motions of Saturn's Rings" obtained for him the Adams prize in the University of Cambridge. He received in 1860 the Rumford medal from the Royal Society for his "Researches on the Composition of Colors" and other optical papers. The subject of color Professor Maxwell has treated with great success, both experimentally and theoretically, his papers on the subject extending from 1855 to 1872. His important paper on a "Dynamical Theory of the Electro-magnetic Field," in which he endeavored to explain electric and magnetic forces by means of stresses and motions of the medium, and thus do away with the notion of action at a distance, was read before the Royal Society in 1864, and printed in the "Transactions" of that year. His contributions to the Kinetic theory of gases form one of the most important and valuable of his investigations. His first paper on this subject appeared in the "Philosophical Magazine" of 1860, and he at different times since published various others. Before him, Clausius had made a great advance by his explanation by this theory of the relation between the volume, temperature, and pressure of a gas, the cooling of it by expansion, and the slowness of diffusion and conduction of heat in it. An investigation was also made by him of the relation between the length of the mean free path of a particle, the number of particles in a given space, and their least distance when in collision. Maxwell by an investigation of the collisions of a number of perfectly elastic spheres, first when they are all of the same mass, and then when they are of different masses, reached the law of Gay-Lussac, that in a unit of volume there is the same number of particles in all gases when at the same temperature and pressure. He also explained gaseous friction, and showed that the coefficient of viscosity is independent of the density of the gas. The approximate length of the mean free path was first deduced by him from data furnished by Stokes.

Pursuing the same subject, he made a few years later a valuable series of experimental investigations on the viscosity and internal friction of air and other gases, the results of which were brought to the attention of the Royal Society in 1866. A paper on "A Method of making a Direct Comparison of Electrostatic with Electro-magnetic Force, with a Note on the Electro-magnetic Theory of Light," was also presented to that body in 1868. He took great interest in graphical statics, and contributed in 1869 a paper on the subject, under the title "On Reciprocal Figures, Forms, and Diagrams of Forces," to the Royal Society of Edinburgh. Besides his numerous articles giving the results of investigations, a few only of which are above mentioned, he contributed to the "Encyclopædia Britannica" the articles "Atom," "Attraction," "Capillary Action," "Constitution of Bodies," "Diagrams," "Diffusion," "Ether," "Faraday," and "Harmonic Analysis." Of the works published by Professor Maxwell, that on "Electricity and Magnetism" is his most important, giving the results of his laborious life in this department of physics. Besides this, a work on "The Theory of Heat," and a small text-book on "Matter and Motion" have been published by him. To these must be added his recently published volume on the "Electrical Researches of the Hon. Henry Cavendish," which he has enriched with copious and valuable notes.

Of his more important pieces of experimental work, that connected with the determination of the British Association Unit of Electric Resistance and his verification of Ohm's law made by him at the Cavendish Laboratory, should be here mentioned.

Professor Maxwell was Fellow of the Royal Societies of Edinburgh and London, and of the Cambridge Philosophical Society, and a voluminous contributor to their "Transactions." In 1872 he was elected Honorary Fellow of Trinity College, Cambridge, and in the same year was created honorary LL. D. of Edinburgh, while in 1876 he received the honorary degree of D. C. L. at Oxford. He was appointed honorary member of the American Academy of Arts and Sciences, of Boston, in 1874; member of the American Philosophical Society of Philadelphia, 1875; and honorary member of the New York Academy of Sciences in 1876. He was also correspondent in the mathematical class to the Imperial Academy of Sciences, Göttingen; corresponding member of the Imperial Academy of Sciences, Vienna; and associate of the Amsterdam Royal Academy of Sciences.

Professor Maxwell did not confine himself to scientific research and exposition, but occasionally appeared in the field of literature with poetic effusions of a satirical character on scientific subjects.

Professor Tait, in his review in "Nature" of Professor Maxwell's work, hopes "that these scattered gems may be collected and published, for they are of the very highest interest, as the work during leisure hours of one of the most piercing intellects of modern times. Every one of them contains evidence of close and accurate thought, and many are in the happiest form of epigram." Two samples of this poetic work are given by Professor Tait, one of which we append:

"To follow my thoughts as they go on,
 Electrodes I'd place in my brain;
Nay, I'd swallow a live entozoön,
 New feelings of life to obtain."

CORRESPONDENCE.

AMHERST COLLEGE AND EVOLUTION.

Messrs. Editors.

AFTER the publication of President Seelye's peculiar statement with respect to the teaching at Amherst College regarding the law of evolution, feeling a graduate's interest in the matter, I made careful inquiry, and find that, at a meeting of the faculty held a few years ago, the present Professor of Geology was requested by President Stearns to deliver a course of lectures on evolution, and the faculty, without any audible dissent, seconded the request. At the time, this Professor was known to believe in the evolution law. Since then, evolution has been taught in the department of zoölogy, the Professor or instructor giving such an exposition of the facts favoring and seeming to militate against the doctrine as would be suitable to students. By vote of the faculty, also, Dana's and Le Conte's text-books are used, both of which accept evolution, the second very positively. There is now established an instructorship in biology. Moreover, I learn that every professor in the scientific departments of study believes in the doctrine in question. The following language, with which one of the professors is credited, shows quite a different state of feeling in the institution from what President Seelye would lead us to believe: "Taking all the relations, as I judge them from my standpoint, it must be concluded that the truth lies somewhere within the lines of the evolution theories. Such unquestionably is the teaching of real science in nearly all places where it has both freedom and intelligence. As to its materialistic or atheistic tendencies, I regard it as having none whatever, except in the hollow brains of those would-be sages who talk most concerning that of which they know the least. The most important point is to find out the truth in nature, and teach that, regardless of all bearing it may have on any of our preconceived notions."

Upon this state of facts, certainly very different from that which the ordinary reader would infer from President Seelye's statement (it is not entirely clear what he means), it may be concluded that Amherst College is working along abreast of the best thought of the time, notwithstanding the unfavorable reflection cast upon it by its President's remarks. There was a period when Amherst College had a reputation for its achievements in the field of science. Latterly, it has ceased to have much in that direction, chiefly because dominated by the influence of the teaching in its senior class-room, under the name of mental and moral science, of a collection of *bizarre* doctrines, expressed in words which have no corresponding thoughts, wholly unscientific and without any philosophical substance or consistency. Since President Seelye thinks he believes in these doctrines, it is hardly to be expected that he could apprehend the truth of statements which express laws of nature scientifically ascertained and verified. The only way in which he could be made to see such truth would be for him to follow the course found necessary by some of his graduates, namely, to unlearn everything taught at Amherst as philosophy, before attempting to take a step forward in the path of true philosophical knowledge.

Of course, to the world of scholars at large, President Seelye's strictures, if they were meant to have application broadly to the doctrine of evolution, will not have the slightest interest; but it ought not to be pleasant for those who have any especial regard for the college to see its president putting forth, in an apparently ill-tempered fling, a statement characterizing unfairly a doctrine which a large portion of the scientific and philosophical world accepts as a natural law abundantly verified, and creating an impression, with respect to the college teaching, which does not seem to be true, and which, if it were true, would only bring discredit upon the institution.

DANIEL G. THOMPSON.

NEW YORK CITY, *February* 10, 1880.

A CONSIDERATION OF SUICIDE.

Messrs. Editors.

THE article under this heading, in your April number, is an ingenious discussion of the subject, and one which also, considering the solemn matter of which it treats, we must suppose to be *ingenuous*, although through the entire argument runs the flaw of an erroneous definition. "What is suicide?" asks the writer, and answers, "The voluntary termination of one's own life." Perhaps we should be content with calling this definition imperfect. It has certainly led the writer into error, and to a distinction between egoistic and altruistic suicide, which has no foundation either in ethics or in the definitions of criminal law. There is no such thing as altruistic suicide. Suicide is characterized by the *intention* to take one's own life. A voluntary death characterized by the intention to save life is certainly not suicide. To constitute suicide there must be criminal motive, just as in the case of any other crime. It must be *felo de se;* in its simplest statement, self-murder. This, in fact, is the definition of Blackstone: "The act of designedly destroying one's own life committed by a person of years of discretion and of sound mind; self-murder." It must be distinguished, that is, from simple voluntary death, as murder is distinguished from simple homicide. There must be the intent to destroy life from a selfish or malign motive. The unjustifiable motive in the case of the suicide is the selfish desire to terminate life, and thus avoid some present or threatened evil, without regard to the evil or unhappiness inflicted on survivors. In the strongest case that can be put, that of an aged man who feels that he is a burden on his friends (or those who should be such), a pure and unselfish motive would incline him rather to inflict that burden on them than the far heavier burden and disgrace of a (to him) criminal and (to them) criminating death.

For the rest—and to embrace under one head all Mr. Hopkins's illustrations of altruistic suicides, viz., heroes, martyrs, and engineers—the man who dies *defending or maintaining a trust* is in no sense a suicide. His death is made to him, by *moral reasons*, inevitable.

W. W. Lord.

Cooperstown, New York, *March* 10, 1880.

"ORIGIN OF CRIMINAL LAW."

Messrs. Editors.

Charles J. Buell calls attention in your April number to some statements in Mr. W. W. Billson's article, "The Origin of Criminal Law," illustrating the way in which early law-makers seem to have taken the revengeful feelings of the aggrieved parties into consideration in imposing punishments upon wrong-doers.

He says: "There appears to be something of this sort in the custom that will hold a man blameless if he shoot and kill the midnight robber who is merely *trying* to *effect* an entrance into his house, but will not hold him guiltless if he take the same sort of vengeance on the robber after he has once *entered* the house and *stolen* the goods and *escaped* with them."

This law is based upon a principle as far as possible from the idea of gratifying the injured party's sense of revenge.

When a man awakes in the night-time and finds another man trying to get into his house, he is not obliged to ask him if he intends to steal or *murder*. The man within may be timid; he may apprehend great personal danger; he may have the impression that an attempt is being made to murder him. The law protects him in acting upon such apprehension. This is simply self-defense. There is no question of anger or revenge about it.

Now, when the robber has made off with the goods, and all possible fear of personal violence has vanished, or can not possibly arise, it then becomes a question, merely, of the "prevention of crime." Society ignores all idea of carrying out the spirit of revenge that may fill the breast of the injured party—in fact punishes him, if he attempts to do so himself, as a criminal. Clearly, whatever may have been the guiding principle of the ancient law-giver, our present legislators do not attempt to administer to personal resentment. The object and reasons for the existence of government have been inquired into, and a scientific basis is gradually building for the great modern structure to rest upon. The passions are found to be the most unsafe guides. Only a few rules of law, relating almost wholly to domestic relations, rest upon them. The consequence is, that these relations figure most disgustingly in the proceedings of courts.

Yours respectfully,

W. C. Albro, LL. B.

Poughkeepsie, New York, *March* 19, 1880.

EDITOR'S TABLE.

MATTHEW ARNOLD ON COPYRIGHT.

THE question of international copyright, as we have maintained on all occasions, is for the people of this country a very serious one. It is commonly regarded that our present condition in respect to it is merely an imperfect state of things which nobody knows how to remedy, and which need not much disquiet us, as it is happily working very much to our advantage. Why, it is asked, should we pick a quarrel with our own bread and butter, especially when the bread is buttered so thickly on both sides?

The reason why the matter is grave

is that the bread and butter are both stolen, and because theft is bad for those who lose their property, and worse for those who get it. A nation can not tolerate palpable dishonesty without vital injury to itself. One injustice leads to another, and demoralization spreads. Selfish advantages openly override correct principles, and then, worst of all, come the mental obliquity and confusion resulting from attempts to palliate and excuse injustice. If a flagrant wrong is long and widely practiced, there will always be plenty to rally for its defense—some dishonestly, from interested motives, and others with a senseless sincerity from innate crookedness, cloudiness, or eccentricity of mind. These crotchety, whimsical, and erratic intellects are found both at home and abroad, and they often prove capable of doing considerable mischief.

Matthew Arnold affords the last example of this mental freakishness, in his article on the copyright question, in the March "Fortnightly Review." The article has excited a good deal of comment, and no little commendation, but it seems to us eminently unsatisfactory. We find no fault with the conclusion at which he arrives, which was intimated years ago, when he joined fifty other English authors in recommending the scheme of international copyright, which originated in this country, and which there has been much reason for thinking could be practically carried out. But, while Mr. Arnold's decision is sound, we think it would have been wise if he had withheld his reasons for it. They are not such as will bring other men to the same result. They are such as will carry other men to the opposite conclusion. So far as logic is concerned, Mr. Arnold takes substantially the same ground as that taken by Mr. J. M. Stoddart, the Philadelphia publisher, who is engaged in pirating the "Encyclopædia Britannica." They both agree that nobody's rights are violated, as there are no rights in the case. Mr. Arnold's point of view in regard to copyright is quite his own. Here, as everywhere else, he is haunted by the spirit of "Philistinism." The undesirable practice of appropriating an author's works is a miserable piece of middle-class indelicacy. "The spirit of the American community and Government is the spirit, I suppose, of a middle-class society of our race, and this is not a spirit of delicacy. One could not say that in their public acts they showed in general a spirit of delicacy; certainly they have not shown that spirit in dealing with authors."

Mr. Arnold pursues this thought more fully. He says: "The interests of English authors will never be safe in America until the community as a community gets the sense in a higher degree than it has now for acting with delicacy. It is the sense of delicacy which has to be appealed to, not the sense of honesty. Englishmen are fond of making the American appropriation of their books a question of honesty; they call the appropriation stealing; if an English author drops his handkerchief in Massachusetts they say the natives may not go off with it, but if he drops his poem they may. This style of talking is exaggerated and false; there is a breach of delicacy in reprinting the foreigner's poem without his consent, there is no breach of honesty. But a finely touched nature, in men or nations, will respect the sense of delicacy in itself, not less than the sense of honesty."

Now, there can not be the slightest objection to this appeal to the sense of delicacy and honor in the effort to secure legal protection to the property of authors. It may be that there are those who would be moved by this consideration and no other; and if Mr. Arnold had been content to devote his paper to this view of the case, there would have been no reason to complain of him.

But, instead of strengthening the case, he shifts its ground in such a way as completely to surrender it. It was not at all necessary to his argument from "delicacy" that he should deny the bearing of moral considerations upon the question; but this he has done in a way that, so far as it has any influence at all, will strengthen the hands of the inveterate enemies of copyright. He intensifies the discords upon a subject which many seem bent upon befogging and distracting by all the arts of ingenious sophistry. He professes to be friendly to copyright, and then reasons his way to the destruction of all copy-*right* by denying that there is any right or wrong in the matter. This reasoning is as follows: "Now, for me the matter is simplified by my believing that men, if they go into their own minds and deal quite freely with their own consciousness, will find that they have not any natural rights at all. And as it so happens with a difficult matter of dispute, so it happens here: the difficulty, the embarrassment, the need for drawing subtile distinctions and for devising subtile means of escape from them when the right of property is under discussion, arise from one's having first built up the idea of natural right as a wall to run one's head against. An author has no natural right to a property in his production. But then neither has he a natural right to anything whatever which he may produce or acquire. What is true is, that a man has a strong instinct making him seek to possess what he has produced or acquired, to have it at his disposal; that he finds pleasure in so having it, and finds profit. The instinct is natural and salutary, although it may be over-stimulated and indulged to excess. One of the first objects of men in combining themselves in society has been to afford to the individual, in his pursuit of this instinct, the sanction and assistance of the laws so far as may be consistent with the general advantage of the community. The author, like other people, seeks the pleasure and the profit of having at his own disposal what he produces. Literary production, wherever it is sound, is its own exceeding great reward; but that does not destroy or diminish the author's desire and claim to be allowed to have at his disposal, like other people, that which he produces, and to be free to turn it to account."

Mr. Arnold here discredits as groundless and illusory that whole order of ethical conceptions which we have been wont to regard as fundamental in relation to human conduct. Whether he scouts all morality does not appear, but he denies it at least in one class of human actions. Though dealing with transactions between man and man which involve the ideas of "possession," "appropriation of property," "robbery," "criminality," "penalty," etc., he never refers to such things as "justice," "equity," "duty," "right," and "wrong," or any principles of obligation. Though all men recognize these conceptions, though the government of society is founded upon them, and though men are fined, imprisoned, and strangled, accordingly as their actions fail to conform to these fundamental ideas, yet Mr. Arnold airily waives them all aside as irrelevant and impertinent in relation to the subject he is discussing. The reader will notice the wordy circuits by which he avoids all the moral elements of the inquiry. To get rid of any question of rights in this matter, he plucks up by the roots and casts to the winds all natural rights. To him who claims a right to life he virtually says: "Oh! no; you have an instinct to live, which is natural and salutary. You find pleasure in life, but it is its own exceeding great reward, and society graciously allows you to have it at your disposal; but you have no natural right in the matter." He maintains that a man has no right of property in his productions, except "so far as the law may choose to create one for him." But is there no right or wrong in the nature of things by which the law itself is to be shaped, and to which it is the object of all law to give effect? A man creates a work of value into which he has put his time, exertion, substance, and his very blood. Has he a right to the property he has produced against those who covet it? It shall be as the politicians vote, argues Mr. Arnold: "If the ayes have it, he has; if the noes have it, he has not." This is not creditable. Mr. Arnold should cultivate a more intimate communion with the "power that makes for righteousness."

Much is made in this article of the difficulty of securing property in books. Government is, of course, a very imperfect agency, and only partially secures any of its objects. But all other difficulties are as mole-hills to mountains compared with that which Mr. Arnold lends his influence to increase and strengthen.

SCIENCE NOT ATHEISTIC.

We recommend those thoughtless theologians who think they are doing God service by arraying modern physical science against him and charging that it is atheistic, to read the article entitled "God and Nature," by the Lord Bishop of Carlisle. He utters a timely and much-needed rebuke to his careless brethren on this subject. We have been amazed at the fatuity of many divines in the course they have pursued upon this question. Their predecessors have been more wise, and have generally recognized that "the study of nature led up to nature's God"; but now, on the contrary, we are assured that the study of nature leads to the denial of God. What on earth our theological friends are to gain by spreading the belief that physical science is fundamentally irreligious by renouncing and subverting all conception of the Deity, we are at loss to understand. Physical science is not to be put down in this way. It is a great phase of man's mental progress and is destined to increase in influence in an accelerating ratio. There is no doubt, furthermore, that its growth is an invasion of the domain illegitimately held by theology in the past, and threatens the ascendancy of theological systems and ideas. It is hardly to be expected that professed theologians can view this change with complacency, but that affords no excuse for getting into a passion with science, and striving to array religious prejudices against it. Our friends should not forget that the "modern science" upon which they expend their denunciations is a great body of accredited and impregnable truth, and that it is a somewhat serious matter to declare and reiterate the accusation that it is atheistic in its spirit and influence. How far is this from asserting that the demonstrative truth of nature is against the existence of God!—and if scientific men reply to the theologian, "Very well, you know best," where will rest the responsibility?

The Bishop of Carlisle sees that this is a mistaken policy. He says, "It is not desirable that the reproach of atheism should be thrown about rashly"; and, what is more important, he points out that as commonly done it is not true. A very slight examination of the conditions of thought in scientific pursuit forbids the current theological conclusions. He draws a valid distinction between the legitimate, proper, and logical attitude of the scientific mind toward the conception of Deity and the atheistic state of mind; and he strives to mark this distinction by the introduction of a new term. He says: "It seems to me that we want a new word to express the fact that all physical science, properly so called, is compelled by its very nature to take no account of the being of God; as soon as it does this it trenches upon theology and ceases to be physical science. If

I might coin a word, I should say that science was *atheous*, and therefore could not be *atheistic;* that is to say, its investigations and reasonings are by agreement conversant simply with observed facts and conclusions drawn from them, and in this sense it is *atheous*, or without recognition of God. And because it is so, it does not in any way trench upon *theism* or *theology*, and can not be *atheistic*, or in the condition of denying the being of God. Take the case of physical astronomy. To the mathematician the mechanics of the heavens are in no way different from the mechanics of a clock. It is true that the clock must have had a maker; but the mathematician who investigates any problem connected with its mechanism has nothing to do with him as such. The spring, the wheels, the escapement, and the rest of the works are all in their proper places somehow, and it matters nothing to the mathematician how they came there. As a mathematician the investigator of clock-motion takes no account of the existence of clock-makers; but he does not *deny* their existence; he has no hostile feeling toward them; he may be on the very best terms with many of them; it may be that, at the request of one of them who has invented some new movement, he has undertaken the investigations. Precisely in the same way the man who investigates the mechanics of the heavens finds a complicated system of motion, a number of bodies mutually attracting each other and moving according to certain assumed laws. In working out the results of his assumed laws, the mathematician has no reason to consider how the bodies came to be as they are; that they are as they are is not only enough for him, but it would be utterly beyond his province to inquire how they came so to be. Therefore, *so far as his investigations are concerned*, there is no God; or, to use the word above suggested, his investigations are *atheous*. But they are not *atheistic*."

For the further working out of this conception in his article, the Bishop must be held responsible. We only call attention to the position here assumed, as illustrating the progress of a liberal and rational theology.

THE LONDON "TIMES" ON "CEREMONIAL INSTITUTIONS."

The attitude of the British press for the last twenty years toward the writings of Herbert Spencer is a curious study. It was natural enough that Spencer could not get a publisher who would take the pecuniary chances in an interminable system of philosophy opposed to all other systems, and based upon an unaccepted and repugnant doctrine; and so nothing remained for him but to publish himself. The works, at any rate, were thus put squarely upon their merits. The powerful agency of publishers in influencing the press was dispensed with; and, as Spencer was the last man to lift a finger for the procurement of critical favor, his publications were left to themselves, editors being neither directly nor indirectly bribed, placated, or flattered. The consequence was that, with but few exceptions, the books were assailed with such reckless misrepresentations that Spencer was compelled to stop sending copies to the press. Nor did he resume the practice until increasing public interest in his labors coerced critics into more decency and fairness.

Some influential journals, however adopted the policy of silence, ignoring Spencer's books altogether. The "Spectator" has adopted this plan. Not a single one of this author's works has ever been reviewed in that journal; and that they were not thought to be worth reviewing could not be alleged, because the chief editor of the "Spectator," Mr. Hutton, went out of his way to attack Spencer's ethical views in an essay read before the Metaphysical Society, and which he subsequently printed in "Macmillan's Magazine."

The London "Times" also, the organ and oracle of British opinion, has illustrated its idea of fair-play by never criticising or noticing any of Spencer's volumes. These volumes were being widely read; they were molding the opinions of thinkers; they were becoming influential in the universities; they were elaborately criticised in the reviews; they were replied to in numerous pamphlets and books; they were translated into all the Continental languages; they were guiding scientific investigation, and familiarizing the cultivated mind of the age with a new order of ideas, but they were never recognized by the London "Times" any more than if they were non-existent. George Henry Lewes said of Spencer that he alone of all British thinkers had organized a philosophy; but the "Times" had no information about it. The meanness of its course is the more palpable, as it never had any principles of its own to maintain, and said what it pleased on any subject; while Spencer was engaged upon a most formidable undertaking, with immense odds against him. But the "Times" has given in at last. Now that the world's verdict has been decisively rendered, it pluckily determines that this author's work must have attention.

And so it breaks the long silence by an elaborate review of "Ceremonial Institutions." There is nothing noteworthy about the article except the significance of its appearance in the "Times's" columns, and the ludicrous perplexity of the writer's position. He writes as if he thought his readers were asking, after twenty years' reticence, Why are you moved to speak now? The book he reviews is part of a series of works which can not be critically understood without reference to the previous volumes. But there is no reference to them—no intimation as to how Spencer was led to deal with the subject. It is, of course, easy in this way to make such a work appear very deficient, but the critic could do it no justice without convicting the journal in which he wrote of former inexcusable neglect. However, the "Times" has found it desirable to change its tactics, and it will no doubt do better next time.

LITERARY NOTICES.

ENGLAND: HER PEOPLE, POLITY, AND PURSUITS. By T. H. S. ESCOTT. New York: Henry Holt & Co. 1880. Pp. 593. Price, $4.

IN these pages Mr. Escott has endeavored to make a survey of modern England, presenting all the salient features of English social, political, literary, and industrial life in such a way as to give a correct picture. Of course, so large a subject can only be given in outline in this compass, but by a judicious use of materials a very large mass of information has been introduced and the subjects treated in approximately their relative proportions. The life and characteristics of the English village; the position and duties of the great landholders; rural administration and municipal government; the law-courts, the legislature, the crown, as well as the official system, all receive more or less attention. Hotel and traveling facilities and popular amusements receive such notice as their importance warrants. Considerable space is given to the condition and prospects of the working-classes, the relations they hold to the other classes of English society and to the state, and the conditions and some of the causes of poverty among them, and the means employed to alleviate it. Educational systems and measures, the structure of society, the relations of society to politics, commercial and financial features, are treated more or less fully, while a large place is given to the intellectual life, religious, scientific and literary. One of the most noticeable chapters in the book is that devoted to British philosophic thought. It is contributed by Mr. W. L. Courtney, of Oxford, and is an able and appreciative review of the subject. He recognizes fully the importance of the work that has been done by Mr. Herbert Spencer, and gives him the foremost place as a systematic thinker, not only among his contemporaries, but among all English thinkers of the century. Of the other two workers in psychology who have claims to a position somewhere near the level of Mr. Spencer, George Henry Lewes and Alexander Bain, Mr. Courtney gives to Mr. Lewes the higher place. The book is a very readable one, and, from the extent and variety of its information, will prove attractive to a large class of persons.

The Interoceanic Canal and the Monroe Doctrine. New York: G. P. Putnam's Sons. 1880. Pp. 118. Price, $1.

In the pages of this little volume will be found compiled a considerable amount of information concerning the commercial importance of the interoceanic canal, the history of the various schemes for constructing it, and its relation to the interests of the United States. It is a timely summary of the leading general facts regarding the enterprise, but does not go fully into the discussion of the merits of any particular project. The book was evidently prepared for an emergency—the arrival of De Lesseps in this country—with the design of heading him off in his project. Unless there was an unavowed and sinister purpose in its publication, we can not see why it should have been issued anonymously. If its author was interested in a rival scheme, and a man of mark, he would very naturally withhold his name from the title-page; but, in treating a great public interest like this in an open and candid way, there can be no occasion for the concealment of authorship. That the book is aimed at De Lesseps is shown by the prominent use the writer makes of the Monroe doctrine, as a means of defeating a foreign project. We showed last month the humbug of this Monroe-doctrine pretext, and there are plenty of indications that the public is beginning to understand how utterly it is perverted when applied to the cutting of a ship-waterway across the American Isthmus. The book is narrow in spirit, and advocates a bigoted and illiberal national policy, which, if carried out, would become a scandal to American history.

Free Ships. By Captain John Codman.

Labor-making Machinery. By Frederick Perry Powers. Price, 25 cents each.

The Action of the United States Tariff. By Alfred Tylor, F. G. S. New York: G. P. Putnam's Sons. 1880. Price, 10 cents.

In issuing the series of "Economic Monographs," of which the first two pamphlets above are numbers, the Putnams are rendering a valuable service to popular education, in a direction in which enlightenment is greatly needed.

The essay on "Free Ships" is an able discussion of the reasons for the decline of the American carrying-trade, in which the folly and stupidity of our legislation on the subject are clearly shown. Captain Codman points out that this legislation has been continually in the interests of a handful of ship-*builders*, while the vastly larger interests of the ship-*owners* have been systematically ignored. At the time when the carrying-trade of the world was done in wooden ships, Americans were able to build the best and cheapest ships; and England, recognizing the interests of the ship-owners as rightly predominant over those of her ship-builders, allowed her merchants to freely purchase ships wherever they pleased. Under this policy, her carrying-trade thrived, and has continued to thrive. And when American merchants were placed under the same conditions—as they were when our ships were the best that could be had—our carrying-trade also thrived. When iron supplanted wood in ship-construction, and we could, in consequence, no longer build as cheaply as England, our legislators had not the wisdom to follow the policy that had proved so successful in England. Instead of allowing our merchants to purchase vessels where they could get them cheapest, they began fostering the ship-building interest—not by putting a heavy duty on foreign ships, but by prohibiting the purchase of such ships at all. Those engaged in other protected industries have been content with the imposition of onerous duties on competing foreign products, but, if one prefers these, he is at liberty to buy them and pay the duty. This sort of protection is not enough, however, for the ship-builders; nothing short of absolute prohibition has been able to satisfy them. The interests of hundreds of merchants have been ruthlessly sacrificed to serve those of two or three men!

To his essay proper, Captain Codman adds a review of the plans for reviving our carrying-trade put forth by Senator Blaine and Secretary Sherman. The pith of the Captain's argument comes out in the following paragraph in the review of Senator Blaine: "He tells us how Germany has prospered. She has increased her tonnage from 166,000 to 950,000 tons in twenty years, while ours has decreased in that time until it has nearly gone out of sight. Her increase has chiefly been in iron screw-steamships. Where did Germany get those steamships with which she has taken away from us our carrying-trade? She bought them. Why did she buy them? Because she could buy them cheaper than she could build them. Why did she not wait, as we are doing, until they could be built cheaper than they could be bought? Because, in the mean time, England, or some other nation who could buy them, would have the carrying-trade. Who has prevented us from imitating Germany; in fact, from maintaining our carrying-trade, which she has taken from us? Who, but Mr. Blaine and his school of protectionists, who have reversed the fable of the dog in the manger; for the horse has forced the dog to eat his hay?"

Though Captain Codman strongly urges the adoption by Congress of the twenty-first section of Mr. Wood's late tariff bill, he insists that very much more than this is necessary to place our carrying-trade in a healthy position. We not only need the freedom to buy ships where we can get them best and cheapest, but we also need maritime laws that will place us on an equality with our most favored rivals.

In his essay on "Labor-making Machinery," Mr. Powers combats the frequently advanced notion that machinery displaces the workman and renders employment scarce. He insists, on the contrary, that it has been in all cases a great benefit to the laborer, and has multiplied his opportunities of labor, and made his employment steadier. The results of his study of the question he sums up as follows: 1. Machinery has reduced the cost of food, or at least prevented its rising with the increase of population, and has also reduced the cost of clothing and other manufactured goods, conferring two benefits upon the laboring classes. 2. The introduction of machinery has increased the demand for labor. The result has been the increase of the number of persons employed in excess of the increase of population, and an increase in the rates of wages beyond the increase in the cost of living. 3. Machinery has effected a marked reduction in the length of the working-day, and has reduced the amount of muscular exertion requisite in many branches of industry. 4. In so far as machinery has conferred less benefit on American laborers than might have been anticipated, it is attributable chiefly to the fact that European laborers have poured into this country in a flood, especially since 1845, since which time the greatest advances in the introduction of machinery have been made.

The third of these pamphlets is a reprint of a letter by Mr. Tylor to the London "Economist," in which he points out a curious and unsuspected effect of the American tariff. He maintains that, besides the result which a high protective tariff has in increasing the prices of those things protected, it has also the effect of lowering the prices of those things that do not come within its scope. By comparison of the prices of wheat, cotton, and oil through a number of years, he shows that, in consequence of our tariff, Englishmen have been able to procure these indispensable articles from us for considerably less than they could have done in a condition of free exchange. "Wheat," he says, "which had averaged fifty-two shillings per quarter for eighteen years in the several markets of Great Britain, in consequence of the American supply has only averaged forty-eight shillings from 1874 to 1879, and yet these have been years of European scarcity. . . . Merchants were surprised, for no one reckoned upon the effect of the American import duties (when limiting import from Europe) in depressing the price of their exports. They had calculated, in the usual way, that, with an increased food-demand of eighty per cent. from Europe, there should certainly be a great advance in price, instead of which a fall of ten per cent. from the previous average price occurred after 1874." Of cotton, he says: "In 1860 and 1861 the average consumption of cotton in Great Britain was 1,040 million pounds, against 1,229 million pounds in 1878. The price is slightly lower now than it was even in 1860-'61. When we consider the enormous competition for cotton, and the British plant provided for working up nearly 200 million pounds per annum, nothing but the want of the American market for finished goods can have kept the price of cotton down to such a very low figure as that prevailing, almost lower than it ever touched before. . . . One consequence" of this is that "the American cotton-grower has latterly got the minimum instead of the maximum price for his article." Mr. Tylor finds that this fall in price also applies to petroleum, and he humorously observes that the British Government "ought to make a strong remonstrance on this subject. We are at the same time indebted to the United States for their cheap grain, cotton, and petroleum, sold at the cost of production to us, in consequence of this unjust tariff." The view of the subject advanced by Mr. Tylor is well worth the attention of our legislators and economists, and, if borne out by fuller inquiry, will constitute another of those facts which increasing experience is adding to our knowledge, showing the folly of tariff restrictions.

Report of the Department of Public Works of the City of New York. For the Quarter ending June 30, 1879. With a Special Report on the Subject of Water Supply.

The feature of this report that gives it an interest to the general public of New York is the very full and elaborate statement of the condition of the water-supply of the city. The Commissioner, Mr. Campbell, points out in it that the present means of furnishing water are and have been for some years inadequate, and that there is danger, in case of any unusual demand, or a continued drought such as occurred in 1877, of the city suffering from an insufficient supply. The present supply is obtained, as is well known, from the Croton River, through the aqueduct of that name. This was constructed to deliver sixty million gallons daily, but for the past eight or nine years it has been called upon to do a much larger service. The present demand for water is between ninety and one hundred million gallons per day, with an increasing demand of two millions per day for each year. The present system is able to supply this demand only by working much closer to the limit than is advisable. When the new reservoir at the middle branch of the Croton and the dams and flumes to draw upon all the available lakes and ponds in the Croton basin are completed, there will be a storage capacity of nine billion gallons, which will be sufficient to fill the present aqueduct to the extent of its capacity; and, to increase the supply, other conduits, either from the Croton basin or elsewhere, will have to be constructed. With a view of determining what sources of supply were available, surveys have been made of the watershed of the Bronx and Byram Rivers, and of that of the Housatonic River, the results of which are given in the present report. The surveys of the Bronx and Byram Rivers district show that tapping the Bronx a few miles above White Plains, the area drained, including the Rye ponds, is 13·33 square miles, and that the like area for the Byram is 8·66 square miles, giving a total of twenty-two square miles. The waters of the Byram can be diverted into the Bronx by means of a tunnel about twenty-six hundred feet in length, and some open cutting. By constructing proper reservoirs and dams, Mr. G. W. Birdsall, the engineer reporting on the proposed work, estimated that thirty-five hundred million gallons can be stored, and that an average daily supply of twenty million gallons can be obtained from this source. The estimated cost of the work is something over twenty-six hundred thousand dollars. This source of supply will only suffice for a few years, after which a further supply will become necessary. With a view of determining its value as a source for such further supply, the survey of the Housatonic district was made. The work was in charge of Mr. Horace Loomis, who has submitted an excellent report upon the results of his investigations. He found that the waters of this river could be brought to the head of the Croton by three different routes, one of a little less than fifteen miles, another nearly twenty-seven miles, and the third forty-one miles. The shorter route is regarded as impracticable, as the water would have to be raised one hundred and six feet to the conduit. The third route, though the longest, is considered the best for a permanent work of this character. It would consist of thirty miles of open canal, two and one half miles of tunnel, and eight miles of natural watercourses. The area drained by the Housatonic above the point where this conduit would join it is six hundred and thirty-one square miles, and the water that could be delivered into the Croton is estimated at one hundred million gallons daily. The cost of this work to the head of the Croton River is estimated at a little over two million dollars. It is considered that, with the auxiliary supply which this river would furnish, the water-supply of New York would be assured for a number of years. Mr. Campbell urges the necessity of early action, that a work which will necessarily consume a considerable time may be commenced in season to meet the continually augmenting demand for water.

The Theosophist. A Monthly Journal devoted to Oriental Philosophy, Art, Literature, and Occultism: embracing Mesmerism, Spiritualism, and other Secret Sciences. Conducted by H. P. Blavatsky. Subscription price, 10 rupees. Published, 108 Girgaum Back Road, Bombay, India.

This periodical, which was started last October, seems to be the organ of the Theosophical Society that has existence both in New York and Bombay. Colonel Henry S. Olcott is its president and Madame Blavatsky its corresponding secretary. Bombay, we suppose, is now headquarters, as the parties mentioned have recently left New York and established themselves in Bombay, where their organ is now printed. "The Theosophist" is printed in English, but claims to have a universal patronage, being subscribed for in every part of India, in Ceylon, Burmah, on the Persian Gulf, in Egypt, Australia, North and South America, and the chief European countries. Of its contents it is somewhat difficult to speak. A large proportion of its contributions are from writers whose names betray an English origin, but there are many from learned natives of India. We should say that the journal is devoted to mysticism, and is perhaps the purest and most perfect anti-scientific periodical that has ever been started.

Its ideal virtue is evidently to believe. We can gather no intimation that there is any check to this process, nor anything too wild, absurd, or extravagant to be credited. One would think that Colonel Olcott and Madame Blavatsky could have found exercise enough for credulity in New York. But they have sought an Oriental sphere where they can revel in a far richer and wider field of superstition.

It seems there is a Hindoo spiritualism akin to American spiritualism, but still arrogating superiority over it. Mr. Rao Bahadur Janardhan Sakharam Gadgil, LL. B., F. T. S., in a communication to the December "Theosophist," thus contrasts the two systems:

The spiritualists of America and Europe have this truth (the survival and return of spirits) phenomenally demonstrated to them, and so far Eastern philosophy welcomes the movement. But beyond this it can not go; for it finds little reason to congratulate the spiritualists upon the new ideas and aspirations they put forth. That death is the mere separation of the corporeal from the *Jiva*, or soul, that animates it, is a truth admitted in all schools of Oriental philosophy. The Bhagwatgita says that the *Jiva*, which is a part and parcel of myself, that is, Brahm, leaves the corporeal body at the time of death, and it draws in and takes with it the mind and the senses, just as the breeze of air that touches and leaves a flower bears off its perfume. So far Oriental philosophy and Western spiritualism are at one. But it appears that Western spiritualists are drifting into the belief that every human soul, after its severance from the corporeal body which it animated on this earth, remains for ever without another corporeal body; that all human souls can and some do make themselves manifest to living human beings either through the bodies of mediums or by assuming, temporarily, objective forms themselves; that this state of existence is better than the earthly one; and that in their corporeal existence they will develop and attain to the degree of final perfection. Now, Hindoo philosophy and religion teach differently on every one of these points. Though they admit that some human souls may continue for a long time without another corporeal body, still this is the lot of comparatively a few of those only who, during their existence on this earth, led a life of sensual appetites and who died prematurely with the intensity of those carnal desires unabated, and surviving separation from their gross bodies.

It is such souls only that are considered to stick to the earth and become what are called *Pishachas*, or what the Western spiritualists miscall "spirits"! But even these are not considered to continue in this state of existence for ever, nor is this state of existence considered in any way desirable. With regard to the majority of human souls, it is held that, according to their holy or unholy deeds and desires in this life, they go either to higher and better worlds, ending with *Brahma loka* by the *archirádi márga*, or to the nether worlds by the *yama márga*. The former are considered to be temporary elevations to better existences, the latter to worse existences than in this world in human shape.

But the state of existence known as *Pishacha yoni* is regarded in the Hindoo system of philosophy and religion as the most horrible and pitiful that the human soul can enter. The reason of it is that it is the state that comes over the human soul as the result of the baser desires having preponderance at the time of separation from the corporeal body; it is the state in which the capacities for the enjoyment of sensual pleasures are in a developed state, but the soul lacks the means of physical enjoyment, viz., a corporeal body: it is the state in which the soul can never make progress and develop into better existence. It is considered that in this state the soul, being deprived of the means of enjoyment through its own physical body, is perpetually tormented by hunger, appetite, and other bodily desires, and can have only vicarious enjoyment by entering into the living physical bodies of others, or by absorbing the subtilest essences of libations and oblations offered for their own sake. Not all *Pishachas* can enter the living human body of another, and none can enter the body of a holy man—that is, an ascetic or adept in occultism.

Annual Report of Harvard College Observatory.

The Director of the Astronomical Observatory of Harvard College announces in his annual report for 1879 that a subscription of five thousand dollars a year for carrying on the work of the observatory for five years has been completed. The astronomical work of the year at the observatory includes photometric measurements of Japetus, Saturn's outer satellite, photometric observations of the eclipses of Jupiter's satellites, the photometric observation of faint stars as aids to the formation of standards of magnitude, measurements of the planetary nebulæ, and the completion of the observation of the zone of eight thousand stars between 50° and 55° north, which has been going on for eight years. A work of some magnitude has been undertaken in the determination of the light of all the stars visible to the naked eye in the latitude of Cambridge. The report is printed at the University Press, Cambridge, Massachusetts.

History of the English Language. By T. R. Lounsbury, Professor of English in the Sheffield Scientific School of Yale College. New York: Henry Holt & Co. 16mo, pp. 371. Price, $1.

The languages allied to the English are sketched in an introductory chapter. The main subject is treated under the two heads of "General History" and the "History of Inflections." The former part is of more general literary interest. In it we notice a carefully weighed estimate of the effect which the introduction of the mass of French words in the fourteenth century has had on the character and capacity of the language. The second part has been prepared more particularly for special students.

The Mound-Builders: Being an Account of a Remarkable People that once inhabited the Valleys of the Ohio and Mississippi, together with an Investigation into the Archæology of Butler County, Ohio. By J. P. McLean. Illustrated with over One Hundred Figures. Cincinnati: Robert Clarke & Co. 1879. 12mo, pp. 233. Price, $1.50.

As to the general subject, this work attempts to present all the essential facts that have been gathered, without burdening the reader with elaborate speculations. The chapter on Butler County, Ohio, gives the fruits of the original researches and surveys of the author, which he made as thorough and exact as possible, in a county which was once an important seat of the mound-builders. Most of the engravings were made especially for the work, and to them is added a sectional archæological map of Butler County.

Insect Lives, or, Born in Prison. By Julia P. Ballard. Cincinnati: Robert Clarke & Co. Small 4to, pp. 97. Illustrated. Price, $1.

This little work is intended to present the facts of the life-history of moths and butterflies in such a manner as to interest children, and lead them to study and observe for themselves. The author has relied upon and described her own observations.

Eyesight, Good and Bad. By Robert B. Carter, F. R. C. S. London: Macmillan & Co. 1880. Pp. 262. Price, $1.50.

It has been the object of Dr. Carter, in preparing this work, to furnish such information on the structure and function of the eye and to give such hints on the care of the eyesight as everybody should know and take heed of. Experience as an ophthalmologist has shown him the need of such a work, as a large portion of the time of such a practitioner is, he says, "occupied, day after day, in repeating to successive patients precepts and injunctions which ought to be universally known and understood." The work considers the structure of the eye, the action of lenses in forming images, the like action of the eye, and the various ways in which these images are distorted, imperfectly formed, etc., according as the eye is defective. The care of the eyes, the effect on them of natural and artificial illumination, and some practical hints on spectacles, are among the subjects treated. The volume will be found valuable in every household, both as a means of obtaining such knowledge in regard to the eyes as it is important to know and as a convenient reference-book.

The Perception of Space and Matter. By Rev. Johnston Estep Walter. Boston: Estes & Lauriat. 1879. Pp. 451.

In this volume Mr. Walter has propounded a theory of perception differing widely from any of previous writers. He reviews and criticises the theories of Reid, Hamilton, Bain, and Spencer, none of which are to his mind satisfactory explanations of the mode in which we perceive the external world. He denies that the existence of such a world is immediately given in consciousness; or that from our experience of force an idea of an extended external cause can arise; or that the postulating of laws of thought, constraining us to invest the external world with space relations, offers a satisfactory solution of the problem of perception. That which the mind knows immediately is only the way in which it is affected and the relations between those various affections. These relations are, however, only relations of sequence, and there are no elements given in these time-relations by which the mind can arrive at space-relations. In order, therefore, that the mind should be able to clothe external things with space-attributes, it must have immediate knowledge of spatial relations among its own sensations—that is, mind must be extended. "There must be," he says, "something really capable of prompting the mind to look outward. But this condition is not supplied in any mysterious innate laws of cause and effect or of association. It is supplied in the immediate perception of spatial exteriority within the sphere of the mind itself or of its phenomena. . . . We come to think of a cause, or causes, external to and independent of the mind, for the reason only that we previously have had the immediate experience of the mind acting as an external cause, so to speak, on mind." This doctrine of mind being an entity occupying space he regards as satisfactorily resolving the difficulties that have hitherto remained irresolvable. The work is original in its results, lucid in its exposition, and direct in its arguments, and will be found a valuable and interesting discussion of the subject.

The Metaphysics of the School. Vol. I. By Thomas Harper, S. J. London: Macmillan & Co. 1879. Pp. 592. Price, $5.

In the reaction of modern thought against the discussions and teachings of the schoolmen, Mr. Harper thinks there has been little or no discrimination between the good and the bad, and that with some that was frivolous there has been cast aside much that was of value. He avows himself a disciple of the scholastic doctors, and, in the preface to the present volume, undertakes to show that their metaphysics does not deserve the unstinted reproach cast upon it, either on account of its terminology, or of the subjects discussed, or of the manner in which the discussions were carried on. He has, therefore, undertaken to present the essential parts of the writings of the scholastics, especially those of St. Thomas and Saurez, in a form acceptable to modern readers. The exposition will run through four large volumes, of which this is the first.

Vocal Physiology and Hygiene. By Gordon Holmes, L. R. C. P., Edinburgh. Philadelphia: Presley W. Blakiston. 1880. Pp. 266. Price, $2.

The object of this work, the author states in his preface, "is to furnish persons who make an artistic or professional use of the vocal organs with a concise but complete account of those scientific relations of the voice, physical and medical, which are generally only alluded to cursorily, or passed over altogether, in works on elocution and singing." The author gives an historical review of the origin and progress of vocal culture, and considers the relation of sound to the voice, the physical construction of the vocal organs, their physical action, the physiological principles involved, and the hygiene of the voice. Under this latter head he considers the effect on the voice of the use of stimulants and narcotics, the diet, the habits of life, of exercise, etc., and gives some directions for its care and treatment when not in good condition.

Electric Induction. By J. E. H. Gordon, B. A. London: Sampson Low & Co. 1879. Pp. 141.

In the four lectures before the Royal Institution contained in this little volume, Mr. Gordon has undertaken to present such facts in electric induction as go to show what it is, and how it is propagated from the excited to any other body. The question, he says, which for fifty years physicists have been trying to answer, is now, through the experimental and mathematical researches of recent years, in a fair way of being answered, and the object of these lectures has been to present some of the data and reasoning upon which this answer rests. According to him, the present position of science on the subject is, that induction is propagated through space by means of undulations in an ether in a manner similar to light, and all that is at present known points to the ether being the same for both excitations, and the difference of the phenomena being due to differences of vibration. An induced body is in a state of strain which in a good conductor is being constantly relieved, and which in a poor conductor is not so relieved. The lectures, when delivered, were illustrated with a number of delicate experiments, descriptions of which and cuts of the apparatus employed are given in the present volume. The lectures are an excellent example of that clearness and directness of statement by which a naturally abstruse subject is made intelligible and interesting to the lay reader.

Therapeutics and Materia Medica. By C. E. Armand Semple, M. R. C. P. London. Pp. 60.

Forensic Medicine and Toxicology. By W. Douglas Hemming, M. R. S. C. Pp. 72.

Aids to Anatomy. By George Brown, M. R. C. S., L. S. A. New York: G. P. Putnam's Sons. Pp. 64. Price, 50 cts. each.

These are volumes in the "Students' Aids Series," on subjects of technical interest only. In the preface to his volume Dr. Semple states that it is intended to be a companion to his "Aids to Chemistry." A long list of remedies is considered, the doses given following closely those in the "British Pharmacopœia."

In the second of the above volumes, Dr. Hemming considers the questions with which medical men have to be familiar in appearing to testify as experts in cases in law courts, and gives a large amount of information in a compact and concise form.

In "Aids to Anatomy" Dr. Brown has aimed to present the main facts of anatomy in such a way as to be most readily grasped and retained by the student, and to be of value to him in the work of dissection.

Annual Report of the New York Meteorological Observatory for 1878. By Daniel Draper, Director. New York: John F. Hahn, Printer. 1879. Pp. 69.

The year covered by this report completes the tenth of the existence of the observatory, and Mr. Draper gives a summary of its establishment and an account of what has been accomplished in this time. The report states the conditions under which the observatory was begun, gives short abstracts from the reports of each year, describes the different self-recording instruments made and used at the observatory, insists on the desirability of a new observatory, and closes with annual and monthly tables. The report is interesting throughout, but that part of it descriptive of the apparatus is especially so. The instruments, all of which have been invented or improved by Mr. Draper, are fully illustrated and clearly described. An excellent idea of how meteorological inquiries are carried on may be obtained from the report by those interested.

Water-Color Painting. By Aaron Penley. New York: G. P. Putnam's Sons. 1879. Pp. 68. Price, 50 cents.

This little manual of water-color painting seems to have met with a very favorable reception from the public, as this is the thirty-seventh American edition, which is taken from the thirty-eighth English one. The Putnams issue the book as one of their "Popular Art Hand-Book Series," edited by Susan N. Carter, in excellent style. The book aims to instruct the student in the principles of the art, and to give such information regarding practice as to make it a valuable aid to proficiency in such work.

Protection of Forests a Necessity, by S. V. Dorien, touches a subject of most important interest to the people of the United States. It reviews the condition of the several countries in Europe, past and present, as to forests, rainfall, and fertility, with the purpose of showing what is the actual effect of forests upon the humidity of the air and on the power of the soil to absorb and retain moisture. New York: B. Westermann & Co.

Professor Levi Stockbridge, of Amherst, Massachusetts, has published a pamphlet containing an account of investigations which have been conducted at the Agricultural College Experiment Station at Amherst, on the rainfall, the percolation, and evaporation of water from the soil, the temperature of the soil and air, and the deposition of the dew on the soil and the plant. The experiments were conducted with apparatus of various designs devised with reference to the special objects sought in each and under a variety of conditions, and were made to bear on the question whether the moisture that is found in the morning on the surface of the soil and on plants is mostly derived from the air directly or from the soil.

Improved Dwellings for the Laboring Classes, the Need, and the Way to meet it on Strict Commercial Principles in New York and other Cities (G. P. Putnam's Sons, New York), relates one of the most important social questions with which American cities, particularly New York, are concerned. It sketches the need of New York and the extent of it in this matter, and describes much good work that has been done in London, New York, and Brooklyn, in more than one way, for the improvement of tenement-houses and of the life of their occupants.

The Report on Magnetic Determinations in Missouri, made during the Summer of 1879, by Francis E. Nipher, Professor of Physics in Washington University, is accompanied with a map showing the declination lines so far as they have been determined, to which is added a map of the independent preliminary surveys of Professor Hinrichs in Iowa. The isogonic lines show considerable flexures which seem to bear a relation to the drainage systems of the regions.

PUBLICATIONS RECEIVED.

Hampton Tracts. Cleanliness and Disinfection, by Elisha Harris, M. D., pp. 19; and Our Jewels, by Mrs. M. F. Armstrong, pp. 27. New York: G. P. Putnam's Sons. 1879. Price, 5 cents each.

The Native Flowers and Ferns of the United States. By Thomas Meehan. Vol. II. Second Series. Parts 19 and 20. Philadelphia: The American Natural History Publishing Co.

A Dictionary of Music and Musicians. Edited by George Grove, D. C. L. Part 9. Vol. II. London and New York: Macmillan & Co. 1880. Price, $1.25 per part.

Report of the Chamber of Commerce of the State of New York on Railroad Transportation. New York. 1880. Pp. 24.

The Food of Birds. By S. A. Forbes. From "Transactions of Illinois State Horticultural Society." Vol. XIII. 1879. Pp. 57.

Historical Sketch of Henry's Contribution to the Electro-Magnetic Telegraph. By William B. Taylor. Washington. 1879. Pp. 108.

Money and a Measure of Value. By John F. Smith. Oak Lawn (Rhode Island) Home Publishing Co. 1880. Pp. 23. Price, 10 cents.

Three Approximate Solutions of Kepler's Problem. By H. A. Howe, A. M. Cincinnati Society of Natural History. Pp. 6.

A Plea for Cold Climates in the Treatment of Consumption. By Talbot Jones, M. D. Reprint from the "New York Medical Journal." Pp. 32.

"The Oriental and Biblical Journal" Edited by Rev. Stephen D. Peet. Quarterly. Vol. I. No. 1. January, 1880. Chicago: Jameson & Morse. Pp. 48. Price, $2 a year.

Annual Report of the Wisconsin Geological

Survey for 1879. By T. C. Chamberlain. Madison. 1880. Pp. 72.

The Cotton-Worm. By Charles V. Riley. Illustrated. Washington: Government Printing-Office. 1880. Pp. 144.

The Chinch-Bug. By Cyrus Thomas. With Map and Illustrations. Washington: Government Printing-Office. 1879. Pp. 44.

Therapeutic Action of Mercury. By S. V. Clevenger, M. D. Chicago: Knight & Leonard. 1880. Pp. 27.

Extra Meridian Determination of Time. By Ormond Stone, A. M. Cincinnati: Society of Natural History. Pp. 6.

Adulteration of Food. By Albert R. Leeds, Ph. D. From "Third Report of New Jersey State Board of Health." Pp. 18.

A Subject-Index to the Publications of the United States Naval Observatory, 1845-1875. By Edward S. Holden. Washington: Government Printing-Office. 1879. Pp. 74, 4to.

Health and Health-Resorts. By John Wilson, M. D. Philadelphia: Porter & Coates. 1880. Pp. 288.

Our Homes. By Henry Hartshorne, M. D. Philadelphia: Presley Blakiston. 1880. Pp. 149. 50 cents.

Brain and Mind. By Henry S. Drayton and James McNeill. New York: S. R. Wells & Co. 1880. Pp. 334. $1.50.

The Taxidermist's Manual. By Captain Thomas Brown, F. L. S. New York: G. P. Putnam's Sons. 1879. Pp. 204. $1.25.

A Guide to Modern English History. By William Cory. Part 1. New York: Henry Holt & Co. 1880. Pp. 276. $2.

Pay Hospitals. By Henry C. Burdett. Philadelphia: Presley Blakiston. 1880. Pp. 176. $2.25.

Chemistry, Inorganic and Organic, with Experiments. By Charles Loudon Bloxam. Philadelphia: Presley Blakiston. 1880. Pp. 688. $4.

POPULAR MISCELLANY.

Where to find the Crayfish.—Professor Huxley, in his valuable work on the crayfish, published in the "International Scientific Series," tells his readers to study the work with "crayfish in hand." In order that readers may be able to do this, the following localities are given, copied from Dr. Hagen's monograph on the *Astacidæ*, with some localities added by the author: *Vermont:* in affluents of Lake Champlain; at Burlington, Shelburne, Colchester, Chittenden County. *Massachusetts:* Western parts of the State, on the authority of Mr. S. H. Scudder. *New York:* Hudson River and its affluents; Newburg, Fishkill; in the Tioga, affluent of the Susquehanna; at Berkshire, Tioga County; Lake Ontario; Genesee River, at Rochester; Garrison Creek, near Oswego; Lake Oneida; Four-Mile Creek, near Sackett's Harbor; and Grass River, a branch of the St. Lawrence; also at Niagara. *New Jersey:* Essex, Schooley's Mountain, Morris. *Pennsylvania:* in Delaware River (Philadelphia), Schuylkill River (Carlisle, Reading); Susquehanna and its affluents (Hummelstown, Berwick); Ohio River (Pittsburgh). *Maryland:* Havre de Grace. *Virginia:* James River and its affluents (Petersburg), the Rappahannock (Fredericksburg), and Greenbrier River. *District of Columbia:* Georgetown. *North Carolina:* Beaufort. *South Carolina:* Wateree River, Charleston, and Summerville. *Georgia:* Athens, Milledgeville, Roswell. *Florida:* Pensacola. *Alabama:* Huntsville, Mobile. *Mississippi:* Mobile River, Monticello, Rootpond. *Louisiana:* New Orleans, Millikin's Pond. *Tennessee:* Lebanon. *Kentucky:* Mammoth Cave, Little Hickman, Hickman's Landing. *Indiana:* Wabash River (Delphi). *Ohio:* Cincinnati, Columbia, Dayton, Miami River, Kelley Island, Lake Erie. *Michigan:* Lake Superior, and reported from Lake St. Clair. *Wisconsin:* Sugar River, and also reported from Milwaukee. *Minnesota:* Collected by Professor Agassiz at Minnehaha Falls. *Iowa:* Mississippi River at Davenport and Burlington. I have found it in greatest abundance at Dubuque. *Illinois:* Chicago, Evanston, Ogle County, Lawn Ridge, Basson Pudge, Peoria, Athens, Quincy, Belleville, Illinois River and its affluents. *Missouri:* St. Louis, and Osage River. *Arkansas:* One species reported, locality unknown. *Texas:* Between San Antonio and El Paso del Norte. *Nebraska:* One species reported, without locality. *Washington Territory:* Puget Sound. *Oregon:* Astoria, Columbia River, Lake Klamath. *California:* San Francisco. *Canada:* Humbe River, near Toronto; Lake Winnipeg, Saskatchewan and Red Rivers. I have found them in the watercourses of northern Maine, and St. John's River, in New Brunswick. Dr. Hagen's monograph was published ten years ago. Many new localities have been recorded since; doubtless they will be found in every State and Territory in the Union. The animals may be found sheltered under or between loose stones along the edges of brooks and rivers. They are very active in their efforts to escape. Owing to their greenish and brownish hues, it is difficult to find them. They may easily be kept in confinement for a long time, and their movements and habits studied.—Edward S. Morse.

The Winter in Europe.—The earlier part of the winter of 1879–'80, while it was exceptionally mild in America, was distinguished in Europe for its severity. In France it is spoken of as the coldest winter which has been recorded for more than a century. It appears that the temperature of October was a little below the usual mean. November gave twelve days of frost; and December surpassed everything that had been known in Paris, in the intensity and duration of the cold. From the 26th of November to the 28th of December, that is, during thirty-three consecutive days, there was frost every day, and during fourteen days of the period, from the 14th to the 28th of December, the thermometer did not rise above the freezing-point. The beginning of December was tempestuous. The storm-center, coming up from the ocean on the morning of the 3d, passed Paris between the 4th and 5th, accompanied by a rapid depression of the barometer and a perceptible rise of temperature from about 18°. The storm, having caused great damage in France, then went to the east, and gradually diminished in intensity as it passed over Germany. About ten inches of snow fell during this storm, and four inches more on the 8th, after which it cleared off, and the extraordinary cold began. The mean temperature of December in Paris is 38½°; the temperature of December, 1879, was 18·3.° The lowest mean temperatures previously recorded in the present century were in 1812 (30·2°), 1829 (25·7°), and 1840 (27.9°). The nearest approach to the temperature of the last December was probably in December, 1788, but the uncertainty of the observations taken at that period makes an exact comparison impracticable. The temperature on the 10th (–14°) was the lowest ever observed. The cold, at the period of its greatest intensity, on the 9th and 10th, presented a remarkable distribution over the surface of Europe. On the first day, two centers of cold were manifested, one being toward Poland, where the thermometer sunk to –32°, the other in the French departments east of Paris. On the second day, the former center had increased in surface but diminished in intensity, while the second center had extended and had reached Paris, and the cold had increased over nearly the whole of France. The temperature continued high on the borders of the British Channel and the ocean, so that great contrasts were presented in places not very far from each other according as they were near to or removed from the sea. Vegetation suffered from the duration of the cold, so that most of the exotics in the public gardens were killed or greatly injured. A zone of high pressure was established in all the west of Europe after the storm of the beginning of the month, the center of which oscillated from France to Poland and from Austria to Denmark. It was observed that the low temperature was special to the inferior regions of the atmosphere. At the height of a little over a thousand yards the air was much more mild. During the latter part of the month the thermometer on the Puy-de-Dôme was often thirty to forty degrees higher than at Clermont, and on the Pic du Midi it rose every day after the 19th to above the freezing-point, while it was still always below it at Paris. The cold terminated suddenly on the 28th, with a storm from the North Sea; a thaw followed, with destructive floods. A new cold term set in after the 4th of January, with a region of high pressure in the center of Europe. The summits again showed a higher temperature than the base of the mountains. The region of extreme cold was this time, however, in Russia.

M. Marié Davy, Director of the Observatory of Montsouris, remarks, in a communication to the Société Française d'Hygiène, that this has been the sixth severe winter of the century; and the six have recurred with remarkable regularity in periods of two each, viz.: 1788–'89 and 1794–'95, interval six years; 1829–'30 and 1837–'38, interval eight years; 1871–'72 and 1879–'80, interval eight years. These periods were each removed to a medium distance of about forty-two years from each other. The near equality of the periods of recurrence is probably a simple coincidence, but it is nevertheless curious. M. Faye has published an account of the meteorological observations, which have been made to the month of May, 1879, at the observatory of the French missionaries in China, at Zi-ka-wei. From them the director of the observatory draws the conclusions — 1. That storms and tempests, and in general all barometric depressions, are propagated in

China and Japan in the same course as the storms and tempests of the Atlantic which reach Europe; 2. That such storms are independent of the prevailing monsoon, and reciprocally, neither interfering with the other. Thus, says M. Faye, in regions opposed to ours in the northern hemisphere, the storms which we call cyclones or typhoons follow identically the same course, whatever may be the distribution of water and land, whether there are currents of warm water like the Gulf Stream, chains of mountains or not, on their way, whatever may be the direction of the lower winds prevailing in the country. The origin of these gyratory phenomena is, then, in the upper region of the atmosphere, whence, away above all the superficial accidents of the globe, they descend to the ground through the lower strata.

Wild Silks.—That our resources for the production of silk are capable of great enlargement is shown by the fact that heretofore only a few of the numerous insects which form silk and only a small number of the plants on which they feed have been utilized, leaving the greater number of insects and plants still unemployed. The known silk-spinners belong to the two families *Bombycidæ* and *Saturniidæ*, of the Lepidoptera. All of the *Saturniidæ* are silk-spinners, but not all of the *Bombycidæ*. Of the *Saturniidæ*, the British Museum catalogue contains the names of two hundred and ninety-four species, and one hundred more species have been added since the catalogue was published. Mr. Thomas Wardle, in a lecture on the wild silks of India, before the Society of Arts, gave a list of fifty-seven silkworms indigenous to India, of which six mulberry-feeding sorts are domesticated, and the others are wild. Besides the mulberry-feeding worms, of which there are also nine wild species, the cocoons of fourteen wild species are utilized. Of these, the principal species are the *Attacus ricini*, the *Attacus cynthia*, or Eria-worm, the *Antheræa Assama*, or Muga-worm, and the *Antheræa paphia*, or Tusser-worm. The *Attacus ricini* is a native of Assam, and feeds on the castor-oil plant and several other plants of the country. The cocoons can not be reeled, but the fiber is exceedingly well adapted for spinning, can be dyed and printed easily and satisfactorily, and forms a cloth of "incredible durability, the life of one person being seldom sufficient to wear out a garment made of it, so that the same piece descends from mother to daughter." *Attacus cynthia* feeds on the ailantus, and has been successfully domesticated in France and England, where "ailanticulture" has a recognized place in industrial economy. Its silk is not adapted for reeling, but spins well, and there is no doubt, says Mr. Wardle, "that a great future remains for this silk, now that spinning-machinery has been so perfected." The *Attacus Atlas* is almost omnivorous, yields a "decidedly good" silk, and has been recommended for introduction into France. The *Antheræa Assama* yields the Muga silk, which forms one of the chief exports of Assam. Five thousand acres are planted in Assam and some Tipperah villages with food for the worm, and are capable of yielding 123,000 pounds of the fiber. Mr. Wardle reports of the silk that it bleaches well, and takes the dye freely, better than Tusser. The *Antheræa paphia*, from which the Tusser silk is derived, is the most widely distributed as well as the most important of the wild-silk producers of India, and has been utilized for many centuries. It feeds on a variety of plants, among them the castor-oil plant, and begins to spin its cocoons in six weeks from the time it is hatched. The silk is woven and used in the provinces of India in mixed fabrics of cotton woof and Tusser weft, but seems also to be used pure in many cloths. The fiber of this silk is flat, thereby showing a strong difference from that of the mulberry silk, which is round, and to this is ascribed its glassy look. So far from this property being a drawback, the luster seems to be enhanced by it after the fiber has become modified and its flatness has been diffused in the loom. The chief obstacle to the general introduction of this silk is the difficulty with which it is made to take colors. A process has been invented to overcome this by applying oxygen to the natural fawn-colored coloring matter of the fiber, but it is too expensive for general use. Mr. Wardle has found a partial solution of the difficulty in a more thorough cleansing of the native product and better reeling, and has made the silk submit to the dye and to the printing process in a tolerably satisfactory manner. In the undyed state it is the most lustrous of all silks, and is very strong. Some of the prints obtained by Mr. Wardle are beautifully suited to wall-hangings, curtains, coverlets, and all kinds of furniture-work; and, while the material has not quite the brilliancy of the mulberry silk in its printed state, it has a richer and softer surface than those of cretonnes or challis, while its lasting qualities are superior to those of any other material. It is beginning to be largely used in France for fabrics and trimmings in which extreme fineness is not required.

Fertilization of the Algerian Sahara.—Some remarkable transformations in the character of the Algerian Sahara have been effected by irrigation. Under its operation a soil has been constituted, in which the intertropical plants grow with great vigor. A cultivator at Ouargla received several medals at the Parisian Exposition for plants which he had raised on a soil thus prepared. The stories that have been told of the productiveness of the Sahara tax the imagination. Fertility is not limited to any one point. It is exhibited wherever water has been brought to the surface of the soil. Most of the Saharan valleys and the beds of the subterranean streams have water in abundance, and only a small effort is needed to bring it to the surface. Sahara is not all a desert, but contains many considerable tracts which are already fit for cultivation. The success which has attended the efforts so far made to introduce tillage renders it nearly certain that a like reward may be gained from similar applications of labor in other parts. Henceforth it will be safe to say that the transformation of the Sahara is only a question of time, labor, artesian wells, means of communication, and security.

The Source of Marsh-Odors.—M. T. L. Phipson recently read, in the French Academy of Sciences, an account of the substances which he had succeeded in extracting from fresh-water algæ. They are palmelline, xanthophyll, chlorophyll, and characine. The last substance receives its name from the odor of *chara*, a well-defined marshy smell which it gives out. It is lighter than water, on the surface of which it forms minute pellicles, but is very sparingly dissolved. It is obtained by first drying the algæ in the air, and then covering them again with cold water as in the preparation of palmelline. After eight or ten hours, a thin iridescent layer will appear on the surface of the water. This is the odorous substance in question. The liquid should be decanted into a long, narrow tube, and shaken with a quantity of ether. The ether dissolves the characine, and leaves it after evaporation in the form of a white, greasy, volatile substance, not saponifiable, soluble in alcohol and ether, hardly soluble in water, and having a strong characteristic odor of the marsh, which it communicates to the water. After some days it evaporates from the surface of the water, or disappears by oxidation, and the water loses its marshy odor. This odor, so strongly developed in plants of the genus *Chara*, is due to this new substance, which is formed by the plant itself during its life, and is not a product of decomposition. Characine is found in all the terrestrial algæ, and in the confervæ.

A Fossil Ferment.—M. Van Tieghem has called attention, in the French Academy of Sciences, to the evidence of the existence of the butyric ferment, *bacilus amylobacter*, in the coal period, which has been obtained by the microscopic examination of the radicles of conifers that have undergone its action, and are silicified in the phytogenic rocks of Saône-et-Loire. These fossils have been subjected to much study by M. B. Renault, assistant naturalist of the museum. The radicles exhibit precisely the same characteristic marks of alteration as are seen in corresponding radicles of the present epoch, which have been kept under water, and have become the prey of the bacilus. We know that the effect in the latter case is to subject the cellulose of the radicles to the butyric fermentation; and the conclusion is legitimate that the reactions developed in the marshes at the expense of the ligneous matter during the coal period were identical with those from which we observe the same effects now. The importance of these observations will be appreciated by those who are studying the part which causes that are now in operation have played in the geological past.

Managing Horses by Electricity.—An ingenious and efficacious method of subduing savage or restive horses has been brought to the notice of the French Société d'Encouragement by M. Bella, administrator of the Omnibus Company of Paris. It is the invention of M. Defoy, who has illustrated its use by some remarkable exhibitions. The machinery is simple, and consists, as shown in the accompanying figure, of a Clark's magneto-electric apparatus inclosed in a box, which is placed within easy reach

of the driver or rider. A conducting wire running through the reins connects the apparatus with the bit. By turning a handle attached to the electro-magnet, a current is formed which affects the horse's mouth, and so surprises him that he stops and stands still. The most dangerous horse may be subdued in a short time by the application of the electric current, combined with a soothing manner and caresses. M. Bella has described experiments which M. Defoy tried with his apparatus upon some vicious and dangerous horses at the stables of the Omnibus Company. An Hungarian horse, which was considered unsafe to shoe, was brought up to the forge, making evident manifestations of his perversity. In a few minutes after the current was applied to him he allowed himself to be caressed on the shoulders and back, then let his legs be touched and his hind-feet raised; and, finally, suffered the workmen to change his shoes without being restrained or showing any further opposition to the proceedings. A trial of the apparatus was also made in the presence of the director of the Cab Company of Paris upon some horses which it had till then been impossible to shoe. They all yielded to its influence. One of them was accustomed to roll on the ground, strike out, and resist in every possible way. On the first application of the currents, says the director in his report, "To my astonishment they lifted his feet without any great difficulty; at the second, he was as easy to shoe as if he had never opposed the least resistance. The animal was conquered." M. Defoy exhibited before the editor of "La Nature" a dangerous horse, which he arrested instantly after it had sprung into a gallop, by turning the handle of the magneto-electric apparatus. The result is not obtained by any violent or painful action. The current is not strong enough to stupefy the animal; it rather produces in him astonishment, and a disagreeable but not painful sensation of an electrical pricking. The editor of "La Nature" has received the current from the apparatus without experiencing inconvenience. There is nothing in the process to recall the barbarous methods formerly used to subdue animals by force or violence, which hurt them in body and temper. M. Defoy has also invented an electrical stick or switch, which is not less ingenious than his bit. It is a riding-whip containing two conducting wires, which are insulated by leather. The wires terminate in two points set perpendicularly to the whip, and are put in connection, as in the case of the bit, by means of a magneto-electric apparatus. If the horse is in the habit of rearing, it is enough to jog him with the legs as he is preparing to rise, and at the same time apply the points of the electric stick to the top of his shoulders. He will immediately subside and let his head down. So, when a horse tries to turn around, the application of the current to that side of his face toward which he is about to turn will cause him to stop immediately. With the help of this little instrument M. Defoy is able in a little while to make a horse obey all his wishes.

Automatism in Portrait-painting.—Dr. Gaetan Delaunay, in a recent article on this subject, writes that he has often observed that a designer making an extemporaneous sketch of a head involuntarily reproduces his own portrait; and that, having made a scientific study of the fact, he has reached conclusions which are curious, though they are not fully demonstrated. He has been informed by teachers of drawing, painters, and designers, of whom he has made inquiries, that a person tracing with a pencil figures of spontaneous conception will always produce the same head unless he is copying from or imitating a model. M. Luys, professor in the Medical Faculty at Paris, states substantially the same principle in his work on the brain, and explains it by a theory of automatism, or habit. It is illustrated in the works of the French caricaturists. A degree of resemblance may be traced between the design and the designer, whether we consider the work as a whole or in its parts. English painters, endeavoring to represent Frenchmen, give them English characteristics, and French painters invest their figures of foreigners with a French air. So painters of every country impart some of their own national features to their pictures of foreign life, to such a degree that we can generally recognize the nationality of the artist from them. We can not explain the fact better than by supposing that all painters are subject to an irresistible tendency to reproduce their own ethnographic type. Sex exercises a similar influence; little girls amusing themselves at drawing will generally be found making female figures, little boys male figures. Dr. Delaunay has also observed that an artist seeking to represent a woman would always draw the same woman, and has learned from designers that the woman who thus persistently came from their pencil was, of the type which they preferred to all others, the one who figured in their dreams. Rubens is quoted as saying, "I paint women as I love them." Further, artists appear to embody their constitutional features in their figures, and will design large or small subjects according as they are themselves large or small. The figures of portly and vigorous artists will be distinguished by fullness of muscular development. According to this theory, the resemblance extends even to the different parts of the body. Raphael, who preferred to paint Virgins, had a virginal head; Michael Angelo, who had a virile head, put more virility into his creations. If we should go into the room where a deliberative body had sat, and gather up the figures which the members had amused themselves with composing during the tedium of discussion, we would be surprised by observing that each one had sketched something very like his own likeness. Dr. Delaunay has experimented with artists, and with persons who did not know how to draw, and has always found that they made their own profiles in their off-hand sketches. The sketch of an unpracticed person would of course be rude and ungraceful, and an unfair portrait, but there would be traits of resemblance about it sufficient to reveal the author. A friend who had what is called a square head drew a figure which was imperfect enough, but the line defining the back part of the head made a right angle. A person with curled hair is not apt to draw straight hair, but curled; one with straight hair will give his figures hair like his own; a bearded man will give them a full beard, a beardless man none; and peculiarities in the form of the beard are often found reproduced in the drawings. Finally, in the works of imagination of painters and sculptors we may recognize the productions of artists who have all the time multiplied their likenesses in their figures. The same conclusion is applicable to imitative designs. If we have a drawing-class of fifty pupils, having a respectable degree of skill, all drawing at the same head, theoretically we should have fifty heads more or less well executed, but all resembling the model, and consequently one another. This will not, however, be the case. The drawings will differ from each other so obviously that, instead of fifty copies of the same head, there will be fifty different heads. Each pupil executes a different head from the one drawn by his neighbor, and more or less resembling his own head. In proof of this, a letter is quoted from a professor of drawing in a lyceum in Paris, who says: "When our pupils are competing for a prize, they have the same model in view, but each one in copying from it reproduces himself more or less. We may, by simply examining his design, determine whether his face is round, oval, or square, whether it has projecting forms, or a smooth contour with few inequalities." The same is the case with sculptors, and even with costumers, who were found by Dr. Delaunay to be most apt to have figures of their own style in view in fitting their customers.

Echoes in Buildings.—Cords stretched in a kind of network near the ceiling have been recommended for destroying echoes in churches and public halls, and have been tried satisfactorily in St. Peter's Church, Geneva, and in the Assembly Hall of the city offices of Bordeaux, France. When metallic wires are used in the same manner, the resonance is greatly diminished, and is sometimes converted into a musical sound. A remarkable resonance has been noticed in connection with the great staircase of stone in the Walhalla at Regensburg, Germany. The visitor, after going up the first stairs, steps upon a landing from which two other staircases rise in opposite directions. At this point every step calls out a metallic ringing, as if the whole stairs were made of brass. A stamp of the foot on the middle of the landing is answered by a clear, resounding, musical tone. The ringing continues as the visitor goes up the stairs, growing weaker as he approaches the second landing, and finally ceases. The phenomenon is believed to be due to the rapid reflections of the sound-waves between the opposite staircases.

Stammering of the Vocal Cords.—Under this title Dr. Prosser James, of London, describes in the "Lancet" a throat malady, which he says may at times entirely suspend the work of clergymen, lawyers, singers, and others who make professional use of the voice. The disease appears to be due to defective coördination of certain muscles of the larynx, in consequence of which the vocal apparatus fails at intervals to fully obey the will; the failure giving rise to sudden interruptions of the voice, while the articulating power may remain unaffected. As in other impediments of speech the harmonious action of the muscles engaged in articulation may be disturbed, in this case the disordered coördination affects the voice only. The movements required for articulating syllables are perfectly performed, but the production of vocal sound is at intervals suspended. The affection may cause the patient to stop speaking, as he is conscious of what he sometimes calls a "catch in the breath"; or he may continue a sentence from which some words will be lost to the listener. Isolated sounds are usually correctly articulated, even by confirmed stammerers; and the same is true in these vocal impediments; but it is in the rapid emission of certain combinations of sounds that the sudden arrest is liable to occur. Dr. James states that after long and patient observation of the action of the vocal cords, aided by appliances specially devised for the purpose, he was able to obtain ocular demonstration of the presence of the affection; and, once distinguished from other impediments of speech, he found it amenable to treatment.

Stature of the Japanese.—Mrs. Chaplin Ayrton, M. D., has recently published the results of nearly three hundred observations of the height and span of the Japanese. She found the average height to be five feet three inches, and the span four feet eleven inches. In the case of twenty-four women, taken at random, the tallest was a trifle over five feet two inches, and the average was four feet eight inches, with an average span of four feet six inches. The shortness of the span as compared with the height is a general characteristic that is especially marked in the case of the women. Sixty per cent. of the persons measured had the span less than the height, and thirty-three per cent. greater than the height, while in only 6·8 per cent. were the height and span equal. Climate can hardly be made to account satisfactorily for the smallness of the Japanese, for they live in a temperate region, though it is subject to sudden and marked changes. The general use of charcoal-braziers for heating may have something to do with it, by causing them to inhale the carbonic oxides. The characteristic of their food is the rarity of meat and the abundance of salt. Many of the additional causes of the smallness of the Japanese may be so remote as to cease to affect the nation except by hereditary influence.

Aids to Hearing: the Osteophone.—The audiphone and dentaphone, which have been extensively advertised as instruments for aiding the hearing of the deaf, have been objected to on account of mechanical difficulties in using them. The audiphone to a certain extent obscures the features of the person using it—the dentaphone is held more or less in the line of vision; and both instruments require the constant service of the hands when in use. Dr. Charles H. Thomas, of Philadelphia, has devised an instrument that is intended to obviate these difficulties, which he has named the osteophone. It consists of a large receiving diaphragm attached in an arched form to a rod of wood or metal, which rod is bent in the form of a pipe-stem. One end of the rod is to be held firmly between the teeth as a pipe is held, leaving the hands of the listener free for other occupations, while he is able to hear all the sounds that may be conveyed by the diaphragm. The diaphragm is below and away from the face, and comparatively inconspicuous. The inventor suggests that ornamental fans, coated with shellac and tipped with ivory or hard rubber, may be made to answer fairly well for occasional use, but will be unsatisfactory if depended on permanently. Fuller's cardboard, treated with shellac varnish, and dried, makes one of the best of resounding mediums. A piece of yellow pine turned into a trumpet-shape, and placed in the mouth of the deaf person, will convey a good volume of sound, and even a string connecting the upper teeth of the persons conversing perceptibly aids the sound. A small rod of hard wood, connecting the teeth of the two persons, gives a volume of sound many times exceeding that transmitted either by the audiphone or the dentaphone. Sensible vibrations, produced by and corresponding to those of the voice, are propagated in the hard palate and base of the skull of persons speaking in the ordinary tones; and the rod which has just been mentioned will convey the voice distinctly when placed against the skull of the hearer, and will even, according to Dr. Thomas, convey audible speech from the skull of one to that of the other. The efforts to make the audiphone and dentaphone useful as regular instruments of hearing to the deaf have not had satisfactory results. Dr. Thomas acknowledges that the expectations which have been excited on the subject are likely to be disappointed. Those who are able to hear with the aid of the audiphone hear their own voices perfectly without it; while those who are unable to hear their own voices without it can hear nothing with it. Dr. Charles S. Turnbull, of Philadelphia, states in the "Medical and Surgical Reporter" that his experience with these instruments has been as nothing, because the suitable cases were so few and far between. The cases in which they have proved of benefit are cases of acoustic deafness, generally due to middle-ear disease, for which devices of the nature of the ear-trumpet generally afford a more satisfactory remedy than either of the instruments under consideration.

Deterioration of Bookbinding by Illuminating Gas.—Professor William Ripley Nichols publishes an interesting paper on the deterioration of the binding of books in libraries, which is commonly ascribed to the action of sulphuric acid supposed to be generated by burning coal-gas. The agency of sulphuric acid having been disputed by Dr. Wolcott Gibbs and others, Professor Nichols made investigations to determine the question. Having examined a large number of samples of leather in every stage of decay, he found that morocco was but little affected, common sheep binding was attacked, and Russia leather and calf were badly acted upon. An acid taste and an acid reaction were observed that were more marked in proportion as the leather was decayed, and sulphuric acid was found in the extract made from the leather with water, in a similarly increasing proportion. Ammonia was also present, in about such a proportion as in combination with the sulphur would constitute the acid sulphate of ammonia. Samples of fresh leather gave extracts only slightly acid, not enough so to affect the taste, and contained only a minute amount of sulphuric acid in combination. Samples of Russia leather and sheep of good quality yielded from less than a quarter to less than a half of one per cent. of acid, and less than quarter of one per cent. of ammonia. A sample of well-worn but not decayed sheep taken from a Bible more than sixty years old, which had never been exposed to gas, gave 1·42 per cent. of sulphuric acid. Other samples, of very rotten Russia, and of scrapings from a number of books, gave from eight to ten per cent. of sulphuric acid, combined with ammonia. A quantity of rotten leather was carefully extracted with water, and crystals of sulphate of ammonia were obtained from it. It is difficult, in the face of these facts, Professor Nichols urges, to escape the conviction that bindings of Russia, calf, or sheep absorb sulphuric acid when exposed to the products of the combustion of illuminating gas. No other condition to which books are commonly exposed can so well account for the large proportion of acid which was found in the old bindings. It has been objected to this view that sulphurous (not sulphuric) acid is the general product of the combustion of sulphur compounds; but Professor Nichols's analyses of the results of the burning of gas have brought out sulphates with no evidence of the presence of a sulphite. It is admitted to be possible that the disintegration of the leather precedes the absorption of sulphuric acid, and prepares the way for it; and Professor Nichols intends to make experiments for the determination of this question.

NOTES.

We ask the attention of our readers to the premiums offered to new subscribers for "The Popular Science Monthly." No such valuable list of modern scientific works has ever before been prepared for such a purpose; and no other publishing-house in this country or in the world is able to furnish from its own stock such a varied and admirable popular scientific library as that which D. Appleton & Company now present for the choice of those who will become subscribers to this periodical. It is important that its patronage and influence should be increased.

We want the means of improving it. There are thousands of intelligent people who have not yet made its acquaintance; and to reach them we must rely upon the help of our friends, who know what the "Monthly" is worth. We ask each one of our present subscribers to detach the list of premiums from his number, and present it to some reading neighbor who can appreciate and ought to have "The Popular Science Monthly." There can be no better investment of money for individual improvement and sound family education than this. The magazine is worth twice what it costs to any thoughtful man, and when he can get his choice among a hundred sterling books as an extra inducement, which virtually reduces the cost of the "Monthly" to three dollars, he ought certainly to be informed of his advantage.

Dr. Phipson has proposed a new method of solving the question of a cheap household light. He has succeeded, with a comparatively feeble electric current, in perceptibly increasing the phosphorescence of certain bodies which are made faintly light by the rays of the sun. He incloses in a Geissler tube, containing a gas in a more or less rarefied condition, a phosphorescent body, the sulphuret of barium, for instance. By causing a constant current of a certain intensity to pass through the tube, he obtains a uniform and an agreeable light, at an expense which he estimates to be less than that of gaslight.

Dr. Carpenter says the entire absence of sunlight on the deep-sea bottom seems to have the same effect as the darkness of caves, in reducing to a rudimentary condition the eyes of such of their inhabitants as fish and crustacea which ordinarily enjoy visual power; and many of these are provided with enormously long and delicate feelers or hairs, with which they feel their way about, just as a blind man does with his stick.

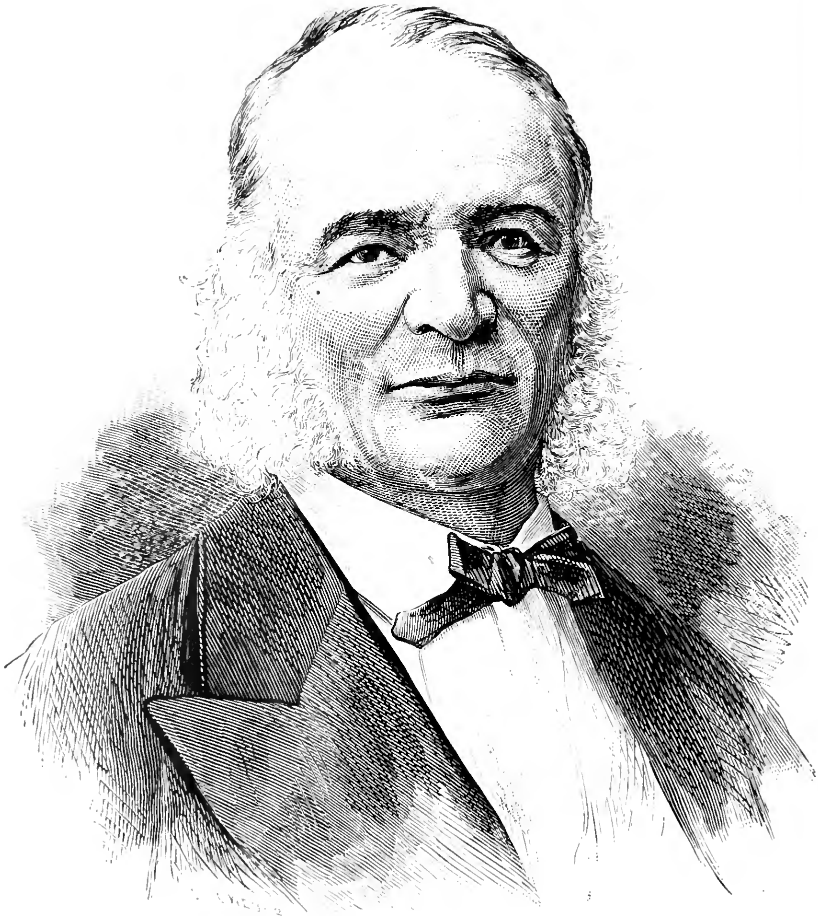
The use of camomile-flowers for the adulteration of smoking-tobacco has recently been discovered in England, just in time to stop an enormous swindle. The flowers are first deprived of their bitter principle by exhaustion in water, and then colored, sweetened, and dried, when they are ready for mixing with cut tobacco. A preparation sold under the name of "The New Smoking Mixture" was found on examination to be about one third tobacco and two thirds camomile-flowers.

Chintamanay Ragoonatha Charry, F. R. A. S., for thirty-five years connected with the Madras Observatory, and for the last seventeen years its head assistant, died on February 3, 1880. Besides a large amount of valuable work, the record of which is confined to the observatory, he contributed several papers to the Royal Astronomical Society of London, and was made a Fellow of that body in January, 1872. He was the first and only native of India who, up to the time of his death, had entered the lists as a discoverer of new celestial objects, having detected two new variable stars—R. Reticuli in 1877, and V. Cephei in 1878. During the later years of his life he delivered popular lectures on astronomy, explaining the principles of the science in simple and familiar terms, with a view to the removal of some of the absurd notions and ignorant superstitions concerning celestial phenomena that are propagated by the Hindoo astrologers.

The first volume of "Studies from the Biological Laboratory of the Johns Hopkins University" is announced. It is made up of original papers on physiology, animal and vegetable morphology, and embryology, contributed by members of the university, and based on investigations conducted in the biological laboratory and marine zoölogical station of the institution. The present volume contains 519 pages, with forty plates and illustrations in the text. Price, $3.50. A volume a year, issued in quarterly parts of about 100 pages, at a dollar each, is contemplated; or it can be obtained at the end of the year, bound complete, for $5. As they are doing some of the best original work in the country at Johns Hopkins, in these departments, those who wish to keep posted in the latest results of biological inquiry will do well to procure these publications as they appear.

Died, March 11th, at Bethlehem, Pennsylvania, Professor William T. Roepper, aged seventy years. Professor Roepper was born in Germany, came to America forty years ago, and in 1866 was appointed to the chair of Mineralogy and Geology in Lehigh University. He gave chief attention to the science of mineralogy, the mathematical relations of crystals and the chemical composition of minerals being subjects of special study. The practical aspects of the science were also of much interest to him, and his services as an expert were often in request.

M. G. Carlet, of France, has been studying the locomotion of insects and arachnids, and reports as the result of his observations that the walking of insects may be represented by that of three men in Indian file, the foremost and hindmost of whom keep step with each other, while the middle one walks in the alternate step. The walking of arachnids is represented by four men in file, the even-numbered ones walking in one step, while the odd-numbered ones walk in the alternate step.



OTTO WILHELM STRUVE.

THE

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THE CLASSICS THAT EDUCATE US.

By PAUL R. SHIPMAN.

I HAVE great respect for the classics, and would do anything within reason to spread the knowledge of them; but a preliminary question must first be answered. *What* the classics are is not a matter of dispute, all agreeing that they are literary masterpieces, the study of which serves above all other studies to refine and liberalize the mind. But *where* are they? As to this, opinions differ.

"The Greeks, madam," replied John Randolph, when Mrs. Jellyby asked him to contribute aid to that suffering people—"the Greeks are at your door." And some people think the classics are in the same vicinity; dwelling, that is to say, in our mother-tongue in the sense in which the needy are at hand—not exclusively, but in such wise as to deserve our first attention. The President of Harvard College is one of these people. "I may avow," says President Eliot, "as the result of my reading and observation in the matter of education, that I recognize but one mental acquisition as an essential part of the education of a lady or a gentleman—namely, an accurate and refined use of the mother-tongue. Greek, Latin, French, German, mathematics, natural and physical science, metaphysics, history, and æsthetics are all profitable and delightful, both as training and as acquisitions, to him who studies them with intelligence and love, but not one of them has the least claim to be called an acquisition essential to a liberal education, or an essential part of a sound training." He adds: "The fruit of liberal education is not learning, but the capacity and desire to learn; not knowledge but power." This is explicit enough. For my own part, I agree to it.

But some people do not—affirming, contrariwise, that a knowledge of Latin and Greek is essential to a liberal education. Among these people is Mr. W. T. Harris, a distinguished educator of St. Louis, and one of the most acceptable of the lecturers, if not the most acceptable, in Mr. Alcott's Summer School of Philosophy at Concord. "Mr. Harris," writes one describing this New England reproduction of the Academy of Plato, "is the star of the school, it would appear, since every one agrees that he is extremely interesting to hear, though few pretend to understand him, and those who do find their profession treated with incredulity." I confess myself a little surprised to learn that he proves unintelligible to any of the men and maidens of the new Academy, especially the maidens, for it is an article of faith in the "provinces" that the average maiden of New England, whatever may be the limitations of her father and big brothers, can understand anything, from the calculus of quaternions to the metaphysics of transcendentalism. Rufus Choate, it is told, once met Jeremiah Mason, with a daughter on each arm, returning from a lecture of Emerson's. "Well, Mr. Mason," said Choate, "you have been to hear Mr. Emerson!" "Yes!" sighed the venerable jurist. "And did you understand him?" continued Choate. "No," he replied, arching his eyebrows, and dropping a glance on either damsel, "but my *daughters* did!" I sincerely hope that the average maiden of New England has suffered no decline in these latter days. And yet a horrible suspicion intrudes itself. Can it be that much Greek has made her soft at last? However this may be, it can hardly excite surprise that Mr. Harris, teaching in the grove of Alcott, as Plato taught in that of Academus, and teaching, it would seem, with quite as many bees in his bonnet, if not on his lips, differs with President Eliot as to the special whereabout of the classics, or, what comes to the same thing, the essential part of a liberal education. It is not to be expected that one who comes forward to revive the Academy would go back on the Greeks. Yet he is none the less entitled to a fair hearing.

"The settlement of this old dispute," Mr. Harris says in a recent lecture, "lies involved in the question, What are insight-giving studies?" And the general principle that determines what are insight-giving studies, he insists, is this: "They must be of such a character that they lead the individual out of his immediate and familiar surroundings, and cause him to breathe the atmosphere and become familiar with the accessory conditions of an earlier historical stage of the people from whom he derives his culture and forms of civilization." This general principle he afterward compresses into the following paradox: "Self-alienation is necessary to self-knowledge." Under this principle he in conclusion thus sums up his position concerning the classics: "Not only for English-speaking nations, but for all modern Europeans, for the reason that they have derived their culture from Greece and Rome, the special culture-studies are Latin and Greek. The embryology of modern civilization is to be found in the literature and institutions of these wonderful peoples." "Mathematics," he declares in the course of the lecture, "as the science of the general relations of time and space, the conditions under which existence in nature is possible, has the same relation to the insight of man into the physical world that classic study has to his insight into the world of institutions." These extracts, if I mistake not, fairly represent Mr. Harris's argument. Seeing that he is a very able and accomplished man, I take it for granted that his argument, as it is the last that has been delivered, is the best that can be made.

What Mr. Harris says of mathematics appears to me in itself to reduce his conclusion to something inconsistent with reason; not that he claims too much for mathematics in the sphere of physics, but that, in claiming as much for Latin and Greek outside of that sphere, he puts a contingent manifestation of mind on a level with the laws of mental processes, coördinating an artificial product with a formal science, two things of wholly different orders, and making the former a key to life as the latter is a key to nature. This at least betrays confusion of thought. If what Mr. Harris wants is a study that has the same relation to "the world of institutions" that mathematics has to "the physical world," he should take not Latin and Greek but logic, a science of the same order as mathematics, and dealing with thought precisely as mathematics deals with quantity. If he does not want a study of this kind, he should not represent what he does want as being such a study, and commend it on the strength of this fallacious representation. Latin and Greek certainly do not form such a study.

But "self-alienation is necessary to self-knowledge," says Mr. Harris; and the study of Latin and Greek, he maintains, is the surest way to bring about "self-alienation," which we may presume to have been the notion passing in the mind of Festus when he made that famous exclamation in the hall of audience at Cæsarea: "Paul thou art beside thyself; much learning doth make thee mad." And, truly, if a man has made up his mind to inflict "self-alienation" on himself, Latin and Greek will answer the purpose; but, before he drains the fatal cup, he should find out, if possible, exactly what he will make by it. A wise man considers the article before he decides to pay the price. Mr. Harris concedes that the "higher abstract elements" of the ancient civilizations can be reached through translation, but not, or at any rate not adequately, he says, the "earlier stages of growth—those of feeling and phantasy." These, as he contends, translation loses "in a large measure"; so that how the Greeks and Latins felt, and what they fancied, can be adequately seized only by "learning to think in their idioms, and to give our thoughts their forms and words." Here we have the article, with the price marked on it: a "large measure" of the "feelings and phantasies" of the Greeks and Latins, in return for learning to think in their idioms. Is not the price a little steep, considering the flatness of the article? Admitting that a full knowledge of the "feelings and phantasies" in question can not be got by translation, and can be got by "self-alienation," is not "self-alienation," as defined by Mr. Harris, too much to pay for it? Whatever the value of the knowledge, who, for the sake of getting it, could reasonably spend the best years of his life, or any of his years, in trying to make himself a Roman and a Greek rolled into one? And who of all this breathing world has tried it and succeeded? Has Mr. Harris? Can he himself think in the idioms of the Greeks and Latins, and give his thoughts their forms and words? I do him the credit to believe that he can not, but, if he could, the fact, I venture to suggest, would rather explain his alleged obscurity in the use of his own language than prove the necessity of mastering theirs; for it would be only natural that one who had carried "self-alienation" to this length should not be at home in his vernacular. He who travels out of himself so far will be apt never to get back again. In his case there would be no "Return of the Native." The "grand tour" would *finish* his education, no doubt, in the primary sense of the word. A kind of culture such a man might have, but it would not be liberal culture, to which, on the contrary, it would bear scarcely more resemblance than a Strasburg goose to the noble fowl apostrophized in the lines of Bryant. It would be an intellectual monstrosity. But "self-alienation" to this degree is happily out of the question. For all, except one in a myriad, it is simply impossible. This explodes the argument as put by Mr. Harris. If the study of Latin and Greek to the only pitch adequate is not a possibility, what is the use of studying them at all? Mr. Harris can have no answer, unless he recasts his argument, which he can hardly do, I think, to any better purpose.

For, is there a modicum of truth in his paradox? In what sense is "self-alienation" in any degree "necessary to self-knowledge," or, which is more to the purpose, self-culture, because the end of liberal education, as President Eliot says, is "not knowledge but power"? The true condition of culture is self-activity, and how far is this determined by that "self-alienation" which consists in projecting one's self into the idioms of a dead language? Nearly as far, perhaps, as would be the corporal activity of one who should take a "header" into the Dead Sea, and essay to cleave its dense waves, beating against his breast like sledge-hammers. A dead language is the Dead Sea of thought, if it may not be more aptly likened to the Sea of Tranquillity in the moon. We think in our mother-tongue only, through which only, therefore, our self-activity is determined, and by which only, for that reason, we cultivate our minds. Our mother-tongue is the sole medium of our mental development. Only by means of it can we even *self-alienate* ourselves. A dead language is a counteractive instrumentality; for which reason we can no more develop our minds freely in Greek or Latin than we can develop our muscles in "twisted gyves." Studying to think in a dead language is shackling the mind, instead of liberating it, and must lead not to a free but to an arrested development. "Self-alienation," if I may be allowed to aphorize a little, too, is self-repression, which will stunt the developing intellect, though it may stimulate the developed one. Culture, be it observed, is not capacity but the growth of capacity, and that which might energize the one would paralyze the other, the full-formed organ deriving strength from what may deaden the rudiment. The study of foreign languages, in place of being the means of culture, is simply a means of knowledge, and the study of the dead languages is not a necessary or convenient means to that. Our mother-tongue alone, as the instrument of our thinking, is the instrument of our culture. It is hence the thing of all things that we should master first and master thoroughly. In this philosophy and common sense are at one.

But the obvious way to master our mother-tongue is to study *that*, and not the mother-tongue of somebody else—to study it in its own masterpieces, not excluding indeed its adopted ones, whether from the Greek or Latin or any other original, but studying these in its own idioms, forms, and words, not in theirs. If there is to be any *alienation* in the matter, let the Greeks and Latins suffer it; they are dead, and it will not hurt them. Us it will hurt of necessity, since it will hinder our mastery of the tongue whereby we think, and by which, consequently, we master our faculties. Here, doubtless, I shall be confronted with the necessity of "self-alienation" as a means of knowing our mother-tongue itself, and not unlikely be reminded of Goethe's aphorism, of which Mr. Harris's is a tolerable equivalent: "He who is acquainted with no foreign tongue knows nothing of his own." To this there are two answers: it is irrational, and imposing facts contradict it. Strictly speaking, the converse of the proposition is true: he who knows nothing of his own tongue knows nothing of any other, for it is through his own that he becomes acquainted with another. The literal aphorism is literally preposterous. Assuming that it means in reality, what is the least admissible meaning, that he who is acquainted with no foreign tongue is not a master of his own, it is still irrational. What constitutes the mastery of a tongue? The "accurate and refined use" of it. And what, by common consent, is the criterion of this use? The established practice of the best writers and speakers of the tongue. Then how can the use be acquired better than by the study of these writers and speakers? Nay, how otherwise can it be acquired at all? And why is the study of any other tongue necessary? We can conform to the use of the best writers and speakers only by studying their works, and, when we have done this effectually, we have nothing else to do; the habit of conformity is established—the use is acquired. One does not learn to employ the brush by handling the chisel, or to shoot a rifle by throwing a boomerang; yet he could do either about as well as learn to use his native tongue by studying a foreign one, from which the incidental gain to his vocabulary would be offset by the loss to his syntax, while the linguistic learning that he might gather would be likely to cramp his expression as much as it enlarged his knowledge, leaving him, so far as the use of his own tongue is concerned, where he started, if not considerably behind that point. On the other hand, the study of his own tongue in its masterpieces would enrich his vocabulary, without corrupting his syntax, and perfect his expression, as well as enlarge his knowledge. In short, the study of it would make him a master of it. Respecting the descent of the tongue, as respecting the "embryology of modern civilization," he has no call to trouble himself till he has achieved this mastery, if ever. The one belongs to the philosophy of language, as the other to the philosophy of history. Neither has anything special to do with the use of English, which either would help him to master not less possibly and surely not much more than ontology or ontogeny or any other recondite study, that he may find it profitable or agreeable to pursue after (but not before) he has equipped himself for anything and everything by mastering his faculties, through the mastery of his native tongue. If for this, however, the study of the tongue in its sources were essential, he would have to go back not to Latin and Greek, which have only multiplied its words and modified some of its forms, but to Anglo-Saxon and the cognate languages, whence come the bulk of its working vocabulary and all its grammatical principles; but this study, as I have intimated, is not essential to culture. A scientific knowledge of our mother-tongue is no more essential to the accurate and refined use of it than a knowledge of anatomy is essential to the graceful and effective use of our limbs; for what Bacon says of commonwealths and virtue is far more true of linguistics and culture—they nourish culture grown, but do not much mend the seeds. If I had my way in the halls of education, I would not only dismiss Latin and Greek, but send off packing along with them the historical and comparative study of English itself, and, bringing to the front, say, mathematics, chemistry, physiology, and philosophy, natural, moral, and mental, put the whole training squad under the immediate command of Captain English—not the fossil infant of the Cædmon age, but the living man of the nineteenth century, with whom we all have a speaking acquaintance at least. Glossology is important in its place, but it has no proper place in a scheme of education. Putting English glossology into such a scheme, after putting out the dead languages, has the appearance of giving a sop to the classical Cerberus—a weak concession to the enemy. Erudition, it should never be forgotten, is not education, nor the means to it; on the contrary, education is the means to erudition, as to every other spoil of intellect. And education, it can not be too often repeated, is essentially and preeminently the mastery of one's own language; for which the masterpieces of the language are not merely indispensable but enough. Sufficient for the mastery of English is the study thereof. The aphorism of Goethe is as false in spirit as it is absurd in letter.

Small wonder that imposing facts contradict it. The Greeks themselves were acquainted with no foreign tongue. Did they know nothing of their own? They declined to seek culture in "self-alienation," as they might have done, by studying to think in the idioms and to give their thoughts the forms and words of the Pelasgians, Egyptians, Phœnicians, or Persians, although some of them, it is true, when already cultivated, picked up what they thought worth taking among the intellectual possessions of these people, as was sensible; but their own language was the exclusive instrument of their culture, as the study of it was their exclusive means of knowing it. The "special-culture study" of the Greeks was their mother-tongue; and the method that sufficed for them—which trained Homer, Socrates, Plato, Thucydides, Demosthenes—will suffice for us. It has sufficed for us. Shakespeare, the greatest master of expression that the race has produced, knew no tongue but his own; and from the solar splendor of this supreme instance the argument, as no English scholar need be told, shades downward through one radiant name after another in the firmament of our literature. And the method is vindicated by not less significant products in other tongues, as witness, notably, the Icelandic "Njála," a biographical work at once of surpassing excellence in style and of purely native culture. Witness, furthermore, the Chinese, who, though the Chinese language consists of upward of forty thousand characters, and is in other respects amazingly cumbrous, have made of their vernacular, by dint of studying it exclusively, and in spite of the pernicious extreme to which they have carried exclusiveness in other directions, an instrument of culture that turns out, in the department of affairs at all events, some of the most highly developed intellects of the time. Sir Frederick Bruce, who represented the British Government at Washington after having represented it at Peking, avowed when in this country that the ablest statesman he had ever met was a mandarin. The Chinese, by the way, make dwarf trees, of which they are very proud, by cutting off the tap-roots, and resting the mutilated ends against stones, thereby striking at the seat of vigorous growth; but, taking no pride in dwarf intellects, their plan of education goes on the opposite principle—the tap-root of the mother-tongue being carefully preserved, never cramped, and continually nourished, the upshot of which is that, while they keep dwarfs in their flower-pots, they have giants in their councils. The facts of which these are examples admit of no answer. They make short work of Goethe's aphorism, and its pretty offspring, the paradox of Harris, breaking down their letter, cutting up their spirit, and sweeping them away to a common limbo. Nor do they leave any solid ground in a course of English for the Anglo-Saxon and its Teutonic congeners. What knew Demosthenes, for instance, of the lineage and affinities of Greek? Before they were fixed he was dead, and, for that matter, Greek itself was dying, although Plato, Aristotle, and some others, to be sure, had touched upon certain aspects of the subject. And what did Shakespeare know of the philology of English? It is a common saying that Shakespeare knew everything, and indeed he knew the human mind so well that he easily divined its possibilities, not simply beyond his own positive knowledge, but beyond the positive attainments of the race, the head-light of his genius having thrown a blaze along the track of human progress to the other side of stations that the imperial train has been generations in approaching and which it has not yet passed; but intuition, though divine, can not do much with the hidden roots of a language, which call for the grub-axe of the grammarian rather than for the scimetar of the poet, and it is not too much to say that the man who knew everything knew next to nothing of philology. Other instances need not be adduced. To back these would be to gild refined gold.

Not only is our mother-tongue, then, the instrument of our culture, but the way to master it is to study it, in lieu of any foreign tongue, living or dead. For English-speaking people the "special-culture study" is not Latin and Greek or either, but English. The mother-tongue, if I may recur to the botanical figure, is the tap-root of the tree of mind, whereof no other tongue can be more than a rootlet. Neglect it, and you dwarf the intellect; cherish it, and the intellect shoots up into full stature. Our mother-tongue is the source of our mental growth. The time-worn notion opposed to this not only is false, but its falsity is susceptible of demonstration in the strict sense of the term.

A curious question remains: How is it that a notion so contrary to reason and experience has dominated the world for century after century? Of course, there is a cause for this effect. What is it? At the bottom or near the bottom of our mental nature lies a propensity which, as related to the intellect, is called *imitativeness*, and, as related to the will, may be called *sequaciousness*. It is, we all have reason to know, an active agent in the formation of whatever we become—the shuttle, if I may so call it, of the loom of man, shooting its double thread back and forth through the warp of his existence. If some order of superior beings, capable by hypothesis of anything, should take it into their heads to strike a medal expressive in a general way of their sense of human character, and drop it from the clouds, it would probably bear the image of a monkey on the obverse face, and on the reverse that of a sheep; and we should all have to acknowledge, with such grace as we could muster, the palpable hit of our celestial satirists. Certain it is that, when we see a thing done by somebody else in the line of our aspirations, we incline to do it ourselves, and to keep on doing it, until some other body, of higher skill or greater force, does some other thing in the same line. The flock follows the first sheep that jumps, and jumps to his jumps, till he jumps no more, or is overjumped by another. This is the general movement, subject to diversions, checks, stops, reversals, renewals—all, indeed, proceeding according to the self-same tendency as the general movement, but out of which, together with that movement, comes in the long run true advancement—the cloth of gold of civilization; for it would be a grave mistake, as I have implied, to suppose that this propensity is not of capital importance to the development of man. Without imitativeness, the first and most fruitful years of life would be a blank, to say nothing of the loss to every later year; and without sequaciousness society would run to anarchy, and leap into ruin. The bell-wether principle, it must be admitted, is a large factor in human progress; but, like every other factor, it may be taken too often, making the product not what it should be.

And this undoubtedly is what has happened in the case of education. In the infancy of our tongue, when the learning of the past was locked up in Greek and Latin, and the key to these languages, as well as the care of education, was in the hands of ecclesiastics, the study of the ancient classics became in some sort a necessity, the teachers being unable or unwilling to move in any other direction, and the learners having no choice but to follow. The jump of the ecclesiastical bell-wether drew on the herd, which, having once got under way, has kept on jumping in the same path, and is jumping in it now, when our tongue has grown up into a rich and glorious maturity, when the learning of the past not only has been transfused into it but is a drop in the ocean of its own acquisitions, and when the care of education, in common with other vital interests, is in the hands of the people. For this egregious persistence, however, the propensity I have mentioned is not alone responsible. Many things have coöperated with it. The dead languages, for one thing, have been put on guard at the gate of the professions, obstructing the admission of all to whom they were unknown; and, in case that obstruction fell short of exclusion, spreading the tables inside with their scraps, which haply might cause the bold intruder to repent that he had staid away from the feast of languages, or had not staid away from the feast of reason also. The flower of the youth of successive generations has thus been put under the classic screw. Then, again, many of the masterpieces of our language have been produced by men of classical training, and, pursuant to a familiar fallacy, the production is inferred to have come from the training because it came after it; whereas, it would be nearer the truth to infer that the production was not on account of the training, but in despite of it—the fruit of English training in the face of classical. Nevertheless, the classical has appropriated the credit. Something, likewise, must be imputed to the splendid renown of the Greeks and Latins, as also to the vague but strong attraction of the unknown, which, if we may believe a saying of the Latins themselves, is always thought to be magnificent. Finally, the victims of the dead languages, prompted by a natural pride, have for the most part kept their sacrifice to themselves, either saying nothing of it, or representing it, with half-unconscious guile, as the cream of intellectual sweetness. The inquisitive man who went into a side-show on the invitation of the showman, to see a wagon with one wheel, and saw a wheelbarrow, came out, Mr. Joe Miller avers, with such enthusiasm in his eyes and such laudation on his lips that the bystanders rushed pell-mell to view the marvel, from which they, too, returned in a state of misleading effusiveness. Something must be pardoned to the spirit of getting even ; but more, I should own in candor, to an honest belief in the marvel extolled. Nothing in fact can be more natural than to exaggerate the value of that which has cost us dear, particularly when it is avouched to be invaluable by the practice of venerable institutions, and the authority of illustrious names, not to mention the prescription of centuries. Such, I think, are the chief things which have conspired with the bell-wether bias, to keep up the long, and senseless, and injurious pursuit of free development in the fetters of the ancients.

Be this explanation as it may, it is high time, and past high time, that the pursuit under these conditions were abandoned. It has been continued ages too long. If not abandoned, I am strongly tempted to predict that man, handicapped by the conditions, will be passed by woman, now almost abreast of him, and that before the end of the next century, unless woman gets handicapped herself, our great poets, novelists, historians, scientists, and philosophers—the leaders of thought and masters of style—will wear petticoats or Turkish trousers, and the lords of the creation, sent to the rear, will become hewers of words and drawers of grammar to the weaker vessels—their better-halves in very truth—the real architects of mind and acknowledged captains of civilization. Let the paragon of animals look to his supremacy. If he sticks to the dead languages, I see but one hope for him ; and that is to persuade woman to accept for herself the chains that have been fastened on him, and which he has not had the wit or the manliness to break. This is his only hope, and the fortune of the tailless fox in Æsop admonishes him not to put his trust in this ; although it must be acknowledged, in view of the course of study at such institutions as Smith, Vassar, Wellesley, and Girton, that the modern Reynard seems to be crying up his mutilated extremity with somewhat greater effect than his prototype of old was able to reach. But this, I hope, is more in appearance than in reality. When he of the fable opened his speech against tails, and proceeded with his ingenious reasoning, there were present in the assembly doubtless a few silly foxes who exchanged approving nods, hastily agreed that tails were inconvenient appendages, and perhaps went so far as to cut off their own on the spot, and range themselves ostentatiously under the countenance of the Great Tailless ; but when the speech, clever yet extremely thin, was finished, and the settled sense of the meeting found a fitting voice, there was an end of all that nonsense. And so will probably disappear the folly that breaks out in the curriculum of the institutions above mentioned. If not, and woman, in a vain wish to vindicate her equality with man by claiming the same weight that he foolishly carries, straps on her shoulders the dead languages, one thing is certain: she will never fulfill the proud prediction that I have ventured to make for her, but hereafter, as heretofore, will lag, instead of leading. However, I am not anxious that woman should lead. Nor yet would I have her lag. The best thing for both sexes, and for all rational interests, would be to drop the dead languages out of the scheme of education altogether, and stick to our mother-tongue until we are educated, when the study of foreign languages, dead and living, or any other outlying study that we like, will be in order. In acquiring the use of our faculties through the use of our vernacular, we acquire the key of universal knowledge, with which we may at pleasure unlock any door in that many-mansioned house. But, first, we should possess ourselves of this key. Education, like charity, begins at home. To-day, if we would have fruitful minds, we must cultivate our lingual birthright; to-morrow, if we please, to fresh woods and pastures new. Meantime, let Greek and Latin wait; and when Mr. Harris, or any other representative of those renowned tongues on the Stygian shore, asks us to contribute aid to the suffering classics, let our response be, in the spirit of Randolph's reply to Mrs. Jellyby: "The classics, sir, are at your door."

HYSTERIA AND DEMONISM.*

A STUDY IN MORBID PSYCHOLOGY.

By CHARLES RICHET.

II.

THE word anæsthesia signifies absence of sensibility. In order to comprehend the significance of this symptom, it is important to present a few summary notions relative to sensibility and the sense of touch. The skin of man, like that of all animals, is furnished with innumerable nerves which are sensitive to the most trifling exciting cause, so that, if we touch ever so lightly any point on the skin, the shock communicated to the sensitive nerves of that organ is transmitted to the brain, and provokes there a sensation and a perception. Several modes of sensibility in the skin have been distinguished. Thus by the tactual sensibility we perceive the contact of objects; but this is not all there is of the sense of touch, for at the same time with the contact we are able to feel the temperature and consistency of foreign

* Translated from the "Revue des Deux Mondes" by W. H. Larrabee.

objects. There is also a sensibility belonging to the muscles. When we make a motion—that of closing the hand, for example—we are not only aware of the effort we make to move the fingers and shut up the hand, but we also know that the movement is executed. Everything takes place as if the muscles were sensible, and each of the muscular contractions actually provokes a sensation. We should also distinguish between tactual and muscular sensibility and the sensibility to pain. When the skin is burned, or cut, or torn, the violent shock suffered by the nerves gives rise to a particular sensation, of which we have all had more or less experience, and which is called pain. The word is so clear and the thing so common that no other definition than the word itself is needed.

Some extremely curious observations may be made with patients who are wholly anæsthetic. We may prick them, pinch them, burn them, without their feeling the slightest pain. They do not perceive the contact of the objects that wound them. An experiment which always creates astonishment in persons who are not acquainted with medical practice is, to bandage the eyes of a patient, and scratch along her arm from place to place with a fine needle without her receiving the least intimation from her senses that she is wounded.

Anæsthesia is sometimes general and equally marked on the right and left sides, sometimes limited to a particular region of the body, as the forehead, the chest, or the forearm. Partial anæsthesia may occur even with patients who are only a little hysterical. If we seek to measure the sensibility of the different regions by pricking the skin lightly with a pin, we will often find a small zone of skin that is insensible. The Inquisitors of the sixteenth century had no other way of proceeding than this when they sought for the claw of the devil, only that, instead of touching the skin with pins, they made the executioner stick skewers of iron into all parts of the body. If the accused did not jump with pain at every implantation of the iron, they immediately declared that the devil had put his grip on her. The stigma of Satan was one of the most certain evidences of witchcraft. According to the most precise tokens of the exorcists, the devil's mark had the shape of a hare's paw.

Hysteric anæsthesia is often seated on only one side of the body; the affection in this form is called hemianæsthesia. The insensibility is so exactly limited to one side, that it is enough to go two or three millimetres to the right or left of the middle line of the body to establish the fact of the presence of sensibility or of its absence.

Although many researches have been made to discover the causes of this derangement of the nervous system, no satisfactory solution of the question has been reached yet. It seems to be proved that no material organic injury is connected with hysteria. The nerves of the affected side have the same appearance as the nerves of the healthy side; the marrow and the brains show no swelling, no hæmorrhage.

We have not in this case a disease in which any disorder in the structure of the organ can explain how its function is perverted. What further causes us to believe that it would be wrong to look for an organic hurt where there is only a dynamical perversion is, that hemi-anæsthesias, after having lasted for even four or five years, will sometimes disappear all at once without any appreciable cause of cure, and leave no traces. As we have said, hysteric patients have an uncertain and changing disposition. Their maladies are likewise capricious and fantastical, and will come on without known cause, and disappear in the same way. An insignificant emotion, hardly perceptible, is sometimes enough to dissipate a paralyis of several years' standing. I knew a case of this kind, in which an hysterical patient had been paralyzed for four years, so that she was not able to speak, or eat, or drink, and had to be fed by putting food into her mouth. One evening she spoke out all at once, and said she could eat without being helped. Her sudden cure was unexplainable. Analogous cases, when they take place in the Pyrenees, pass for supernatural and divine manifestations. We judge otherwise in Paris, and see in them only the irregular effects of a disease which is imperfectly understood, the singular and complex nature of which science has not yet unraveled.

Some very strange phenomena have been observed in hysterical patients. It appears to be proved that they can remain a very long time without taking food and without drinking ; at the same time, the secretions seem to be suspended, so that, under certain conditions not yet well determined, there takes place an almost complete cessation of the chemical operations of life, such as does not occur in other persons till the moment of death. "Nature," says M. Charcot, "seems to have a special provision for hysterical persons." The most surprising circumstance is that, although the attack be extremely violent and the alimentation most deficient and poor, the affected persons preserve their plumpness and the usual appearance of health. These facts are certainly not supernatural, though they have not been explained. It is right, then, to be on the guard against seeing in this prolonged abstinence, as they assumed to do in the case of Louise Lateau, a kind of miraculous divine protection. It is also necessary to beware against the simulations which many patients habitually attempt. It would be puzzling to say why they do this unless it be that they lie for the sake of lying, for the mere pleasure of propagating an error, even when that error is not to their profit. Some of the so-called demoniacs in former centuries indulged this curious fancy of making believe that they lived without food. Wier, one of the few persons who ventured to defend good sense against the universal folly of his age, tells how, in 1574, he exposed the tricks of a little beggar, who was probably hysterical, named Barbara, who made herself pass for a prodigy, and pretended not to eat or drink. He took the little mendicant home with him, watched her carefully with the aid of his wife and servant, and so fully laid bare her deceptions that she was compelled to confess, not that she had been playing tricks, but that Wier had cured her.

Wier was not the only person who, even in the sixteenth century, protested against the abuse of the belief in the supernatural. Several educated physicians would not allow themselves to be blinded by the ruling prejudices, and referred nervous affections and convulsions to their true cause, hysteria, which they then called suffocation of the womb, instead of to the devil. It would, however, have been rash for them to deny the action of demons, and they were, therefore, reticent in expression, and used well-rounded phrases to disguise the boldness of their doctrine. "I have seen," says Houlier, "two daughters of a president of one of the Parliaments of France, subject to be taken with such fits of laughing that it was impossible to stop them, either by fright or by threats and scolding." "In suffocations of the womb," says a learned man of the sixteenth century, "incidents frequently occur which cause physicians of little experience to think that it is a case of enchantment or of something extraordinary and supernatural." They had also observed incidents of catalepsy and of burial alive in hysteria, but were very careful against ascribing them to the machinations of the devil.

The efforts of physicians to cure hysteric anæsthesia have only recently been attended with any success. A happy discovery, revealing a series of real but improbable facts, has led to the introduction of salutary modifications in the therapeutics of hysteria. Twenty-five years ago, M. Burq affirmed that the application to the skin of certain metals, as gold, silver, copper, or zinc, would cure neuralgias, headaches, and paralyses, but no one thought of making a scientific verification of his novel assertion. M. Burq passed out of notice, but continued to maintain that the treatment of nervous diseases with metals would lead to marvelous cures. He might, however, have preached in the desert till the end of his days, had it not occurred to M. Charcot to make a test of some of his experiments. He found that M. Burq's representations were correct, at least in part. Though the application of metals gives only moderate results in many nervous diseases, it is nevertheless true that in hysteria, and particularly in anæsthetic hysteria, it is attended with singular modifications in the symptoms. The application of pieces of gold or silver or other metal upon the insensible region is sufficient to produce a complete restoration of sensibility in the course of a few hours. Some patients are cured with gold, others with silver, others with zinc or copper. This process of treatment, which consists in the application of pieces of metal to the skin, is called metallotherapy.

Strange as these facts may appear, they have been verified too many times in France and other countries to permit us to call them in question. Additional researches have disclosed the manner in which the metals act when they are applied to the skin. It is by the development of feeble electric currents in consequence of the contact of the metal with the moist and salty skin. The currents, although they have not enough intensity to be felt, are strong enough to modify the condition of the sensory nerves, cause anæsthesia to disappear, and reëstablish sensibility. Experiments made directly for that object have established the probability of this theory.

Magnets, which may be compared to very feeble electric currents, exert an action on the skin very like that of metals. The phenomena are very clear; but, instead of curing anæsthesia, magnets transfer it, causing it to disappear from one side and pass to the other side. If, for example, we apply a magnet to a patient insensible on the right side, at the end of half an hour the right side will have become sensible while the left side will have lost its sensibility, showing that the disease, instead of disappearing, has been carried over from one side to the other. Does not this facility with which the morbid spot may be moved exclude every hypothesis of a deep material lesion of the nervous centers? The facts of metallotherapy and magnetotherapy are of great interest in physiology as well as in clinics; but the exposition of them is very dry, and even this short glance at them may seem too long. I pass to the description of symptoms which we might call demoniacal, and which constitute the grand attack of hystero-epilepsy.

It would be hard to imagine a more terrible spectacle than that of one of these demoniac fits. The body pulsates with tremors and violent shocks. The muscles are contracted, so tense that we might believe them to be on the point of bursting. Great bounds, frightful cries and howlings, confused vociferations, indescribable contortions which we would not have supposed a human creature capable of making—such is the hideous picture which the hysterical patient presents when she is seized with an attack. After one has witnessed a scene of this character, he will be less astonished that the simple credulity of the men of the middle ages made them see in the phenomena the intervention of evil spirits, and that they supposed that only the devil could provoke such a furious exasperation of all the forces of the body.

As we study more closely the attacks of epileptic hysteria, we perceive that, in the face of this violent appearance of disorder, the disease has its regular, distinct periods. Nothing is at hazard. Every symptom, however unordered it may seem, appears in its turn with a surprising regularity, we might almost say punctuality. M. Charcot and his pupils* have shown that the demoniac fits embrace three well-characterized periods.

* Paul Richer, "Etude descriptive de la grande Attaque hystérique," 1879. The numerous drawings attached to this book, as well as the excellent photographs of MM. Regnard and Bourneville in their "Iconographie photographique de la Salpêtrière," give a very fair idea of the successive periods of the attack.

The first period is analogous to the attack of epilepsy proper. An abrupt loss of consciousness takes place. The patient falls to the floor; her muscles contract, stiffen; her face turns blue; the features are wrought into a horrible grimace; the arms bend; the hands clinch; in a few instants afterward the muscles quiver with convulsive tremblings, which at first grow more marked, then become weaker and weaker. At last, the muscles, exhausted by the long and violent strain, relax, and a deep, stupid sleep succeeds the convulsive spell.

This lasts only for a little while, and then begins the second period, which M. Charcot calls the period of *clownism*, because it recalls the curious attitudes and contortions of the clowns in the circus. At this stage the patient executes prodigious bounds; the body, bent into the arc of a circle, rests on the bed only by the head and feet; the face is disfigured, sometimes terribly so, and the twisted features give it a hideous expression; and at times the whole body will bound up, then fall heavily upon the bed. "The patient goes into a fury against herself," says M. P. Richer, describing one of the attacks; "she tries to scratch her face, to tear her hair, she utters pitiful cries, she hits her breast with her fist so hard that the attendants have to interpose a cushion; she springs at the persons who are around her, tries to bite them, and, if she can not get at them, tears everything within her reach, the bedclothes, her own clothes, bellows like a calf, strikes the bed with her head and her fists as if she could never get enough of it; she jumps up, throws her arms around, bends her legs up and kicks them out again, shakes her head back and forth uttering hoarse cries all the time, or, if she sits down, twists her body around from one side to the other, and keeps her arms moving."

Not less surprising than the violence of the attack is the ease with which it can be stopped. All the excess ceases at once on simply compressing the abdomen. The demoniac spell originates apparently in the ovary, for, on pressing the hand on the abdomen precisely at the point that answers to the ovary, the rage immediately ceases. The poor demoniac, restored to herself, casts an astonished look at the persons around her, as if she does not understand why they are there, for she was alone when she was seized, and has been unconscious since. She keeps her consciousness as long as the ovary is compressed, and is able to put the clothes in order, to talk, laugh, and enjoy herself cheerfully with her associates; but, if the compression is relaxed a little, the attack begins again with all its original force, to cease again if the ovary is compressed anew. By a coarse but intelligible comparison, the working of this pressure may be likened to the action of a faucet on the flow of water in a pipe. The flow ceases when the valve is turned off, to begin again as soon as it is turned on. The patients at the Salpêtrière understand the relation so well that, when one of them is attacked, the others straightway go to her bed and press on her abdomen, for several hours if it is necessary, till the fit is over. The attack is marked by a complete absence of mind. The intellectual life is entirely suspended, but is resumed at the end of the fit, just as if nothing had taken place. If a remark has been begun and is interrupted, it is resumed on recovery at the point where it was interrupted.

We call these attacks indifferently demoniac fits or fits of hystero-epilepsy, because it was believed for a long time that demons were the real living agents that provoked the terrible morbid phenomena. The symptoms are the same, and it is only necessary to read the description of the demoniac attacks of the past to recognize their identity in all points with the hystero-epileptic fits of the present. Esprit de Bosrager, a Capuchin father, who was charged with the exorcising of the nuns of Louviers,* tells pertinently to this point: "On the day of Pentecost (1644), the same Dagon (this was the name of the devil that possessed Sister Marie du Saint Esprit) kept up for four good hours the greatest rebellion that could be imagined to prevent the girl from communicating, and during all this time he made her suffer extraordinary convulsions, threw her to the ground several times, forced her to make a hundred leaps, a hundred courses round the church, made her push at people, strike them, and throw them down . . . . Oh, what astonishing motions! what wonderful contortions! what furious rolling, sometimes into a ball, sometimes into horrible shapes! What numerous and rude convulsions in such delicate creatures, and with so frequent repetition and reënforcement! I should have to be persuaded very much, I assure you, before I would believe that sensible and judicious men would make all those convulsions pass for disease and all those wonderful movements and rollings for juggler's tricks. But what ought to convince every human mind as by a demonstration, what admits of no reply, and what all the famous doctors have acknowledged, is this: that it is quite impossible that convulsions, and such terrible ones, should come naturally by disease, should last so long, should return so frequently, should not leave lassitude after they had passed, and, finally, that they should not destroy the subject."

With all respect to the brave Capuchin, these spells of demonomania are a veritable disease. We are able to class the symptoms, distinguish the phases, the beginning, the middle, and the end, and we can affirm that the "wonderful rollings" of Sister Marie de Louviers belong to the second period of the hystero-epileptic fit.

The strange acrobatic attitudes which characterized the preceding phase are not observed in the third period. The limbs are no longer

* "La Piété Affligée"; or, "An Historical and Theological Discourse on the Possession of the Nuns called of St. Elizabeth at Louviers, by Esprit de Bosrager, Capuchin, Rouen, 1752," pp. 257. This is the work, otherwise very curious, which Michelet calls an immortal book in the annals of human folly. The author's style may be judged from the quotation.

cast about in every way, in obedience to the exaggerated excitation of the spinal marrow. Cerebral life, which has been suspended since the beginning of the attack, has returned, and consciousness has, at least partially, appeared again. Now, hallucinations of every kind arise, sometimes gay, sometimes sad, sometimes amorous, sometimes religious or ecstatic. Whenever any image rises in the mind, the movements of the limbs, the expression of the face, the general attitude of the body, respond at once to its character. These poses, these passional attitudes, have a vivacity, a vigor of expression, that can not be found anywhere else. The most skillful actor would never be competent to represent fear, menace, anger, with as much truthfulness and power as these poor hysterical girls, whose demeanor is influenced by the agitations of a raving and changeable delirium. One crosses her arms and raises her eyes to heaven in an attitude of religious admiration, as if she saw the clouds opening to show her the saints or God. Another talks in tender words to her little girl, from whom she has been separated for a long time. Another sees monstrous animals, lizards with red snouts and blood-shot eyes, or enormous bats, and her features express unspeakable horror. Generally there are two types of delirium, gay and melancholy, answering to corresponding forms of hallucination. The two frequently appear in combination, taking each other's place with marvelous rapidity. M. ——, says M. Paul Richer, "is with Ernest* at a pleasure-party in a restaurant near Paris, where the tables are set under trellises adorned with flowers and climbing plants. At the right is a negress surrounded with strong-armed black men who are tattooed, and entirely naked, who seize her by the hair and are about to scalp her. The blood runs in streams over the face of the unfortunate woman, who utters lamentable cries, and calls for help. On the left is a very different spectacle: Ernest has a throng of friends who accompany other young women. All the personages have no other clothing than a broad, red girdle, except Ernest, who wears a Spanish costume. They sit at the table, eat oysters, drink of a white wine, sing, and laugh." Each patient generally has a form of delirium peculiar to herself, so that the different attacks in the same subject always bear a resemblance to one another. The same personages appear, the same scenes are repeated in all the attacks. The order in which the hallucinations come on does not vary, and one who has witnessed a few attacks suffered by the same patient can always judge when the end of the fit is near from the nature of these hallucinations. With one, it is indicated by a flourish of military music; with another, by the noise of a railroad-train; with another, by the appearance of monstrous animals—vipers, crows, frogs, rats. The regularity of these mad deliria is indeed surprising. Listening to the vociferations, the howlings of the sufferers, it would seem as if chance alone directed the

* Names of young people have taken the place of the names of devils which the demoniacs formerly gave to the personages of their hallucinations.

horrible drama. In reality, all is foreordained, regulated. The tumult goes on with the mathematical precision of a well-adjusted clock.

Fantastic as the delirium of the patients during their attack may appear, it always has a cause and occasion. The hallucinations of a demoniac resemble the real episodes of her life, particularly the one which has had the most influence in the development of her malady. It is true, as we have already said, that the principal cause of hysteria is hereditary predisposition ; still, an accident is needed, an exterior provocation for the first nervous crisis, some event which may be grave or light, to determine the outbreak of a malady which has been brooding for a long time. This event is often a fright, a violent emotion, some grief, a disillusion. Then, in the attacks of delirium, the things and persons that were the occasion of the emotion—fright, grief—reappear as hallucinations. This influence of what has happened in the past establishes an important difference between the delirium of the insane and that of persons suffering from hysteria. The visions of the insane, whatever they may be, generally have no immediate relation to anterior events, while the form of delirium in hysteria is nearly always determined by an incident which has formerly played an important part in the life of the patient. The visions of beasts and monsters are common to all delirium. They appear whenever a fever has deranged the cerebral functions, and are the generally recognized marks of alcoholic delirium.

The period of delirium which indicates the ending of the attack is sometimes quite short. More often it is prolonged for several hours, and not rarely it persists for some days. The cerebral functions have been deeply troubled, and they return very slowly to their normal condition. It is, however, hardly proper to use this expression to describe the intelligence of the hysterical patients as it is observed during the intervals between their fits. Intelligence, it is true, is not extinguished ; the memory, the keystone of the intellectual arch, is preserved ; but the other faculties are singularly perverted. We can gain a good idea of their condition by studying the manners and the conversation of the demoniacs in the Salpêtrière. They pass the day in continual laughing at things that have nothing laughable in them—at the servant-maid who passes by, for example, at a badly made bed, at a bird that perches near the window, at a badly fastened bonnet. The same causes will as readily provoke tears. Interminable conversations are always going on, recriminations, with indignation drowned in a flood of words. With all this is combined an unceasing movement which has no real object and can not be explained. The woman must put flowers on the bolster of her bed, a ribbon in her hair, she must decorate herself with gewgaws ; and the busy carefulness in these little matters contrasts with the negligence and disorder of the general keeping ; a patient whose hat is adorned with ribbons will go out barefooted into the court. Odd ideas prevail, and absurd antipathies and sympathies. Hysterical patients demand, more than anything else, that other persons shall be occupied wholly with them, interested in their petty passions, that they take part in their likes and dislikes, that they admire their intelligence or their dress. They tell improbable stories, lie boldly, and are not disconcerted in the least when they are convicted of the lie. Deprived of all moral sense, they obey only because they have no alternative. No feeling of modesty or false shame restrains them; they tell their adventures to any one that comes, provided they are pleased with him, and will talk with men as freely as if they were of their own sex. Nothing embarrasses these female Diogeneses; they have an answer for everything, ask the most indiscreet questions, and tell the truth bluntly to every one. They are not deficient in self-love, and are indignant if one does not appear to be occupied with them. They never hold the same opinion long, and will pass from one sentiment to another with marvelous rapidity. No idea, no reasoning can hold them or persuade them. Their mind wanders from spot to spot without the power to settle itself, and it is as hard to fix the attention of an hysterical person upon a precise idea as it is by reasoning to induce a bird which is hopping about to stop and fix itself on a branch.

These unfortunate creatures are wholly deficient in good sense, and commit all manner of follies when left to themselves. It is necessary to be fully aware of this fact to understand why they are confined in an asylum for the insane; for when we question them, when we converse with them, we do not discover that total perversion of intelligence which we make out so easily with regard to most insane persons. We should have to see them in their working life, that is, in the midst of the exterior world, subjected to the exciting influences of every kind with which it abounds, to comprehend to what extravagances, not to use a stronger term, they will abandon themselves when no restraint hinders them. Sometimes, though rarely, they commit crimes. Most frequently they forge strings of fables to delude justice. One will cut herself with scissors, and pretend that some one has hurt her; another will feign pregnancy in order to make some one whom she hardly knows marry her; another is a kleptomaniac, and when she is in a shop steals everything within her reach, to accuse the first person that comes along of having committed the theft.

No description can be as valuable to convey an understanding of the nature of the disorders of the intelligence which hysteria causes as the simple story of a patient who has long been known at the Salpêtrière under the name of G——, and who is distinguished for the eccentricity of her disposition, as well as for the violence of the convulsions from which she suffers. G—— was born at Loudun on the 2d of January, 1843; was abandoned by her mother and put among the foundlings; after having passed her early years in an asylum, she was sent to the country. When fourteen years old she was courted by a young man named Camille, but at the end of a year her affianced died of a brain-fever. She was shut up during the funeral, to prevent a scene, but got out of the window, ran to the cemetery, and wanted to throw herself into the grave. She was confined again, but went to the cemetery in the night, calling on her lover and wishing to dig up his body. She was afterward seized with a nervous fit, during which she appeared to be dead, and continued for about twenty-four hours in a complete lethargy. After two years more of residence in the asylum she seemed to have nearly recovered; then, at seventeen years of age, she took a situation as chambermaid at Poitiers. Her nervous attacks returned in a few weeks; she pretended to be pregnant, was believed, and was sent to the hospital to be confined. The deception was soon exposed, but her attacks had assumed a graver form; she was indomitable and rebellious to all discipline, and was sent to an insane asylum. While the physician was treating her with belladonna, she hid her daily doses of pills for ten days, and then took them all at once. They nearly killed her, but she recovered. She maimed her chest with a pair of scissors, and could not tell why she had done it. She ran away from the hospital and went to Paris, but was attacked again and sent back. She was transferred to the insane asylum at Toulouse, but escaped from there and returned to Paris, walking all the way, if her story is to be believed, dressed in the uniform of the asylum, sleeping in the woods, undressing herself to wash her linen, living on bread which she asked for at the farmhouses, and being three months on the road. She made up her mind, under the pressure of hunger, to beg in spite of her pride, saying that our Lord had asked for alms, and she could do what he had done. She was arrested at a railroad-station for tearing down the placards from the walls. She was taken back to the Salpêtrière, where she gave birth to a daughter in 1867. She escaped in 1870, and became an attendant in the hospital of St. Antoine, but gave way to violence in a dispute with a nun, and was discharged. She started to go to see her daughter in Burgundy after the armistice was signed, but was detained by the Prussians, returned to Paris, and went back to the Salpêtrière. At one time, having read in the papers the stories about the miraculous Louise Lateau, she desired to go to Belgium to visit "her sister." She was attacked with a fit on the way, and met with adventures in Brussels which prevented her making her visit. She finally returned to the Salpêtrière in 1877, and has been there ever since. She suffers from frequent demoniac attacks, but is generally quite docile and reasonable in a certain measure, ready to tell, to any one who will listen to it, her long and improbable history.*

The story of G—— will be read with more interest, if we are able to realize that two hundred and fifty years ago she would have been exorcised, or condemned as a witch and burned alive.

* For a more detailed narrative of the facts relative to G——, see the "Iconographie Photographique," part i., pp. 65, *et seq.*

THE CROSSING OF THE HUMAN RACES.*

By M. A. DE QUATREFAGES.

THE movement of expansion which followed the geographical discoveries of the fifteenth and sixteenth centuries has resulted in transporting to a host of points on the globe not only the European white but also the African negro, who was first carried away into slavery. Everywhere the two races have crossed with each other and with the natives of the place; and everywhere, in consequence of these unions of the two races, mixed populations have appeared, having in varied proportions the blood of the whites, the negroes, and the local races. This is a remarkable fact, which has engaged the attention of travelers, but which the founders of anthropology—Buffon, Blumenbach, and Prichard—and most of their successors, seem to have passed over. I have often pointed out this singular omission, and indicated the causes of it, the chief of which is that those writers were without the documents bearing on the subject which we possess now. I have also tried to fill the gap in the investigation, and, after having studied the phenomena from a general point of view, have shown, I believe, how the study of what has passed and of what is passing now throws light on the origin of populations which are often considered as of a pure race, and how an attentive study may enable us to discover traces of a crossing sometimes too ancient for the remembrance of it to survive, sometimes on the contrary recent enough to permit us to recover historical evidence of it. I have endeavored also to indicate what may be the consequences in the future of contemporary facts.

The conclusions to which this study has led me are in direct disagreement with those of some anthropologists, and in particular with the doctrines advanced by Dr. Nott, the Count de Gobineau, Dr. Perrier, Messrs. David, Turnham, Knox, etc. Without repeating the considerations I have already advanced concerning these differences of opinion, I will here point out what the differences are. Those who disagree with me affirm more or less explicitly that crossing between human races is of itself a cause of decline, and that, when two unequal races intermarry, the mixed population is fatally inferior to both. In the crossing of unequal races the superior is depressed, they say, without raising the inferior. The mixed race is more or less degraded physically, and is deprived of all disposition to work, of all moral force.

Most of the adversaries of crossing still maintain that the formation of a new race resulting from the union of two other races is really impossible. Populations originating thus can not be kept up, they

* Translated and abridged from the "Revue Scientifique."

say, except by the continued accession of new elements from pure races. If they are abandoned to themselves and left to form connections with each other, the mongrels will become infertile after a few generations, and the mixed race will disappear.

None of the eminent men with whom I regret to differ take any account of the influence of the action of the surroundings. I believe that the conditions of the surroundings play as important a part in the crossing of races as they do in other matters. They may sometimes favor, sometimes restrict, sometimes prevent, the establishment of a mixed race. This simple consideration accounts for many apparently contradictory facts. Etwick and Long have affirmed that in Jamaica the mulattoes hold out only because they are constantly recruited by the marriage of whites with negresses. But in San Domingo, in the Dominican Republic, there are, we may say, no whites, and the population consists of two thirds mulattoes and one third negroes. The numbers of the mulattoes are there well kept up by themselves without the introduction of fresh blood. In respect to fertility, different instances of crossing between individuals of the two same races may give different results, according to the place where they are effected. I believe it is unnecessary to insist and show that the physical and physiological faculties of children born of mixed unions ought to present analogous facts.

In my view the aggregation of physical conditions does not in itself alone constitute the environment. Social and moral conditions have an equal part in it. Here, again, it is easy to establish, in the results of crossings, differences which have no other cause than differences in these conditions. It is true that mongrels, born and grown up in the midst of the hatred of the inferior race and the contempt of the superior race, are liable to merit the reproaches which are commonly attached to them. On the other hand, if real marriages take place between the races; and their offspring are placed upon a footing of equality with the mass of the population, they are quite able to reach the general level, and sometimes to display superior qualities.

All of my studies on this question have brought me to the conclusion that the mixture of races has in the past had a great part in the constitution of a large number of actual populations. It is also clear to me that its part in the future will not be less considerable. The movement of expansion, to which I have just called attention, has not slackened since the days of Cortez and Pizarro, but has become more extended and general. The perfection of the means of communication has given it new activity. The people of mixed blood already constitute a considerable part of the population of certain states, and their number is large enough to entitle them to be taken notice of in the population of the whole world.

In using the word (*metis*) mongrel, or person of mixed race, I do not mean the fruit of union between individuals belonging simply to distinct branches of a single great race. By that criterion all Europeans would be mongrels. That kind of crossing has been going on among us since the dawn of the present geological period. We may begin to trace it through prehistoric times; and from the birth of history, even in the legendary form, it appears preparing the way for the actual condition of things. This fact alone unequivocally condemns all the theories which ascribe a degrading influence to intermixture considered by itself.

I refer at present only to mixtures of the white with the negro and other colored races. M. d'Omalius d'Halloy, a Belgian scholar distinguished for his critical spirit, in the last edition of his "Anthropology," fixes the population of the globe at twelve hundred millions, and the number of mongrels from crossings of this kind at eighteen millions. Thus the latter already constitute one sixty-sixth of the whole human race.

The proportion becomes more considerable when we look at some of the states of South America, where the aggregation of circumstances has favored a mixture of races. Statistics already several years old show in Mexico, Guatemala, Colombia, the La Plata, and Brazil, a total of 16,040,100 inhabitants, of whom 3,333,000 are mongrels. The latter, then, form about one fifth of the population. This proportion, high as it is, is really too small, for, since the censuses from which the numbers were borrowed were taken, the mixture of races has increased; again, many persons of mixed blood have been counted as whites. In these countries any one who rises to an honorable position in society can call himself a white, and no one will refuse him the privilege. I know of a family in the best society of one of the Central American states, in which the negro and Indian blood are notably mixed. All of its members pretend to be pure whites and pass for such, and a person who should express any doubt on the subject would be very badly received.

The inhabitants of the province of São Paulo in Brazil are nearly all the mixed issue of marriages contracted by the Portuguese and by whites from the Azores with the native tribes, the Carijos and the Guayanazos.

These facts are significant. They become more so when we recollect how short a time has been necessary to produce such results. In South and Central America, and Mexico, the crossing has been going on on an extensive scale only since the conquest of Mexico and Peru, between 1519 and 1533. Less than three centuries and a half separate us from that epoch—and what are three centuries in the history of mankind? It is easy to believe that in three centuries more the mixture will be complete in that part of the New World.

Are the United States and Canada the theatre of ethnogenic phenomena analogous to those which we have just proved to exist in the countries south of them? The contrary is generally asserted. We have only a few details concerning the mulattoes of the Southern States; and Dr. Nott has strangely contradicted himself in the few generalities he has written on this subject. Travelers sometimes speak of mongrels whom they have met on the confines of the Union or of Canada. But, on the whole, I know nothing precise on the result of the mixture of races in the vast region which extends from the frontiers of Mexico to beyond the Arctic Circle. The work of Mr. Daniel Wilson,* without entirely filling this gap, furnishes some really interesting statements bearing on this subject. It makes known some facts which, although they are presented in a little too general manner and without statistical details, are nevertheless of great value; and it states some others with more detail. Incidentally, it adds its testimony to the evidence which had already been gathered against the common errors which are daily repeated. By these features it merits the attention of anthropologists, and an analysis of some of its details is of interest.

[As Mr. Wilson's book is easily accessible to American readers, we will not repeat in detail the citations which M. de Quatrefages makes from it, but will only give a summary of the argument which he deduces from them.—Editor Popular Science Monthly.]

Mr. Wilson does not dwell at much length on the history of the mulattoes. Having mentioned the opinion of Dr. Nott, who believes that they are infertile, sickly, and destined to extinction, and having referred rapidly to a few local circumstances which seem to support this opinion, he concludes by saying that nothing justifies the conclusion of that anthropologist. His figures seem to be decisive. Carefully compiled statistics show that the number of negroes imported into the United States can not have exceeded four hundred thousand, while the colored race in the country now comprises about five million persons, and is largely composed of mulattoes. Dr. Nott admitted that his statements concerning the debility of the mulattoes applied only to those of South Carolina, and that in Louisiana, Florida, and Alabama, the children of the negro and white were well-formed and prolific. He explained the difference by saying that the Englishman is the only true white, and can not produce a robust offspring with the negro, while the Spaniard and Frenchman, already mixed, are more allied to him, and will cross fruitfully with him. This strange theory is easily refuted by historical arguments. So Dr. Nott's testimony confirms our theory, at least for the three more Southern States. It is shown, then, that the mixed race of black and white is increasing in the southern part of the Union as well as in South America. We can not doubt that, in a future the remoteness of which is dependent on the disappearance of existing prejudices, a fusion will take place between the men of color and the whites.

* "Some American Illustrations of the Evolution of New Varieties of Man," by Daniel Wilson, LL. D., F. R. S. E., University College, Toronto.

The facts related by Mr. Wilson concerning the crossing of the whites with the red Indians and the native races of the North are very instructive. Half-breeds of the local races have associated with Europeans, and been accepted as on terms of equality for a long time. The case has been regarded, however, as exceptional, and it has been believed that ultimately the Indians would be represented only by the relics buried with them in their tombs. Another belief is now gaining ground, that the Indian is not disappearing, but that a mixed race, full of vigor, is being developed faster than superficial observations have enabled us to perceive, and that the indigenous ethnological element is a factor of the population which is destined to exercise a permanent influence upon the Europeo-American race. The official reports show that the Indians have borne the test of endurance everywhere that they have been put upon reservations, as well as everywhere that they have been permitted to associate on equal terms with whites. Sufficient account has not been taken of the fact that the Indian population which thus gives so good an account of itself is not of pure blood. In the territory of the Hudson Bay Company alliances have been formed between both Scotch immigrants and Canadian-French and the Indian women. The difference in paternity is revealed in the offspring, but in both cases the half-breeds are a large race and robust, have greater powers of endurance than the pure Indians, and are intellectually their superiors. Dr. Kane and Dr. Rae have noticed that the half-breeds of Greenland and Labrador are superior in every way to the pure Esquimaux. In these remote regions the mixed race may become fixed and endure ; but, where contact with the white race is more constant and is renewed more frequently, the pure Indian blood will continue to diminish, and will at last disappear, not by extinction, but by absorption. Numerous facts may be adduced to show that this is taking place among the Sioux, among the Cherokees, and among the Indians of Canada. After several crossings the descendants at last pass for whites, and are lost from the account of the Indians, though still transmitting Indian blood. A Huron chief at Jeune-Lorette, Canada, had four children, three daughters and a son. Two of the daughters married French-Canadians, and the other daughter an Irishman ; the son married a Scotch-Canadian woman. The children of the three daughters pass for Europeans, and only those of the son for Indians or half-breeds, although they are all mixed in an equal degree. The same is likely to take place in innumerable cases. Moreover, the white men select the most promising Indian girls, so that the Indians, by this process, give up their best stock to swell the account of the white race.

In the United States and Canada the numerical preponderance and constant influx of Europeans have, if we may use the term, masked the mixed race ; but, in the border regions and the Northwest and in the Hudson Bay Company's territory, the local race and the settlers occupy, in consequence of the superior numbers of the native race, a position analogous to that which they hold in Mexico and Central and South America. Marriage with Indian women is inevitable, and families of a mixed race are growing up everywhere, sharing the ideas and habits of the European father, and destined to mingle with the civilized community on a footing of equality.

These facts show that man is everywhere the same, and that his passions and instincts are independent of the differences that distinguish the human groups. The reason of it, says M. de Quatrefages, is that these differences, however accentuated they may seem to us, are essentially morphological, but do not in any way touch the wholly physiological power of reproduction.

RECENT GEOGRAPHICAL EXPLORATION.*

By Chief Justice DALY.

BEFORE entering upon an account of the geographical work of the world during 1878 and 1879, I would call attention to the great increase during the last few years of geographical societies. Eight have been formed within the last two years alone, and there are now throughout the world fifty-one of these organizations; the last two being one in Algeria and one in Japan. Our own society is the fifth in the number of members, though, as respects its annual revenue and ability to aid in the work of geographical exploration, it is much below bodies in Europe inferior to it in point of numbers. The oldest is the French Geographical Society of Paris, established in 1821; the largest and the most influential are the Royal Geographical Society of London, which has 3,337 members, and an annual income of about $40,000, and the Imperial Geographical Society of St. Petersburg, with an annual income of about $33,000, $12,000 of which is contributed by the Russian Government.

In the department of physical geography, much interesting work has been done. Sir Wyville Thomson, as the result of observations made by him, chiefly in the scientific voyage of the Challenger, finds that many of the physical conditions of the globe depend upon its division into two hemispheres, one embracing nearly the whole of the dry land, and the other almost all the water. He says that all the vast mass of water, often two thousand fathoms in thickness, lying below what he calls the neutral land, moves slowly northward, and that this motion is due to the trade-winds. It is now established, he states, that the average depth of the ocean is about two thousand fathoms, and that

* Abstract of the last annual address before the American Geographical Society by Charles P. Daly, LL. D., President.

it probably nowhere exceeds five thousand; that in depths of about two thousand fathoms there is the *globigerina ooze*, a substance resembling chalk, formed of the shells of living organizations that existed on the surface of the sea, and sunk to the bottom on the death of the animal. This ooze occupies considerable portions of the bed of the Atlantic, Pacific, and Southern Oceans. In depths below three thousand feet an extremely reddish clay is found, which is apparently the decomposition of submarine volcanoes and of decomposed organisms. What is at present forming a great depth does not correspond, either in structure or chemical composition, with any known geological formation, and warrants the belief that none of the older formations of the globe were laid down at such great depths. Sir Wyville Thomson adopts the opinion of Professor Dana, of Yale College, that the eruptions which originated the mountain-chains that form the skeleton of our present continents, and the depressions occupied by our present seas, arose from the cooling and contraction of the crust of the earth at a period more remote than the deposition of the earliest fossiliferous rocks.

Dr. Kroll, of Göttingen, has also been engaged in investigating the depth of the ocean, and estimates the mean depth at 1,877 fathoms, an estimate not very much below that of Sir Wyville Thomson.

In meteorology the most notable phenomena have been the very marked changes of the ordinary temperature in different parts of the world, particularly in western Europe, in certain parts of Asia, and in the eastern portion of the United States. It has been marked in Europe by winters of increased severity and an undue prevalence of moisture in the spring and summer, attended by very disastrous consequences to agriculture in Great Britain, France, and some other countries. The last winter on the European Continent, as well as in Great Britain, has been one of the severest upon record. In France the thermometer has never been so low since 1795, with the exception of one year, 1871, when the cold, however, was but of short duration. In Switzerland and southern Germany, especially in the mountainous parts, the severity of the winter has been exceedingly disastrous; while in this country the winters—especially the present winter—have been of unusual mildness in all the States east of the Mississippi.

In Asia the changes in the ordinary temperature have been equally remarkable. In the mountains of Cashmere there was a snowfall last winter extraordinary even in that mountainous region. In certain places it snowed uninterruptedly and heavily for ten continuous days, the snow upon the level plains being from thirty to forty feet deep, and in some of the mountain-passes it was piled up to a height of one hundred and fifty feet, and in others to two hundred and fifty feet.

Various conjectures have been advanced as to the cause of this unusual change of temperature. A writer in the "New York Herald" attributes the fact that the spring and summer in Europe was excessively rainy to an unusually vigorous movement of the Gulf Stream, in consequence of an exceptional pressure of the southeast trade-winds, which he claims produced an extensive diffusion of Gulf vapor in a northerly direction, greatly mitigating the winds in the United States. Others attribute these effects to a change in the condition of the sun, which during the last year is said to have been in a state of repose that is very rare, there being no spots or eruptions visible upon its surface. The latter theorists maintain that, when the sun-spots are at the greatest height, or at their maximum, the earth receives the greatest quantity of heat; and that, when the spots are at the lowest, or their minimum, the heat is proportionately lessened. Others, however, dispute this altogether, declaring that the observations that have been made of the maximum periods of the spots on the sun's surface do not coincide, over any length of time, with the warm and cold years, and do not, therefore, justify any such inference. Monsieur de Perville, on the other hand, maintains, as the result of long observations of dry and rainy seasons in Europe, that they correspond with known changes of the moon. In connection with which I may mention, as a curious fact, derived from recent Assyrian researches, that the Babylonians and Chaldeans attributed changes in the weather to the influence of the moon, and kept up a system of regular observations of the moon for practical purposes.

The extreme dryness and consequent want of moisture for the fertilization of the fields in parts of India and China, hitherto fruitful and thickly populated, is attributed to the wanton destruction of the forests on the hillsides. In 1879 Mr. Hilliard visited the famine-stricken province of Shang-Si, in China, and found in these famine districts that the trees had been extensively destroyed, and attributes the want of moisture and the consequent infertility of the soil to this cause. Observations made in France by M. Mathieu and by M. Fautral over a period of four years, by different methods, as to the effect under trees and the effect in treeless plains, led to the same general results, which are as follows: That it rains more abundantly over forests than over open ground, especially when the trees are in leaf; that the air above the forest is more saturated with moisture than over the open ground; that the leaves of trees intercept one third, and, in some trees, half of the rainfall, and that the leaves and branches restrain the evaporation of the water which reaches the ground, moistening the earth four times as much as it is moistened by the rain that falls upon open plains.

Geographical inquiries are not limited to the discovery of unknown countries or places, but embrace the discovery of the remains of lost civilizations or cities, one of which has been discovered during the last two years. The readers of the Bible will remember the frequent mention that is made of the Hittites, a people occupying Canaan, who are described in the Biblical narrative as being commercial and military, and in whose country Abraham bought a piece of land for his burial-place. The scattered accounts in the Bible simply indicate an ordinary tribe of people, with whom the Israelites had intercourse, but information derived from the researches made in Egypt and Assyria show that the Hittites, whom the Egyptians called the Kheta, and the Assyrians the Khatti, were a powerful confederacy occupying the country which was the highway between Babylonia or Assyria and Egypt—a people actively engaged in commerce, their principal city being a place at which merchants from all parts congregated, and who were at the same time a warlike people, who for a long period kept the Assyrians in check, and who proved the most formidable antagonists the Egyptians ever encountered. They were not only commercial and warlike, but had evidently at a remote period made great advances in civilization and in the fine arts, and early Greek art, as found in the discoveries of Dr. Schliemann at Mycenæ, and the early art found in Cyprus by General di Cesnola, is supposed to have been largely derived from them. They occupied the whole country of southern Syria, from the Mediterranean to the desert, dwelling chiefly in the fertile valleys of the Orontes, a river rising to the east of Baalbek and flowing into the Mediterranean, and had two principal cities—Kadesh, or the holy city, and a great commercial emporium, which was their capital and the center of their power, called Carchemish. They were finally overthrown by the Assyrians B. C. 718, and had so completely disappeared that they are scarcely even referred to by Greek writers. Great interest was felt to discover the site of their commercial capital, Carchemish, and many conjectures have been made, none of which, however, could be verified. A few years ago Mr. Skene, the British consul at Aleppo, discovered a huge mound of earth, covering a large area, on the western shore of the lower Euphrates, near Déjrabis, a ford of that river on the route still traversed by caravans. This great mound was surrounded by ruined walls and broken towers, while the mound itself was but a mass of earth, fragments of masonry and *débris*. It had frequently been seen by previous travelers, but they identified it with other lost places. Mr. Skene called the attention to it of the late George Smith, the eminent archæologist, who brought so much to light from the ruins of Nineveh, and Mr. Smith found here the long-lost capital of the Hittites. The present British consul, Mr. Henderson, has been during the last two years engaged in the exploration of the mound. He has already sent important remains with inscriptions to the British Museum, and an English traveler, Mr. Sackaw, has been recently engaged in investigating it. A few years ago a stone, which had formed part of the wall of a house at Hameth, had an inscription upon it which excited great curiosity, because it was neither Assyrian nor Egyptian, but something between both languages. It may be remembered that I called attention in one of my former addresses to the discovery of this stone and one or two others containing like characters, which were then called the Hamite inscriptions, with the suggestion that this might probably be the language of the Hittites, which is now proved to be the fact. The inscriptions found by Mr. Henderson in the exploration of Carchemish are not only in the same character, but the same language, which Mr. Layard found impressed upon seals discovered by him in the ruins of the record-chamber of Sennacherib's palace, which greatly excited his curiosity, as the writing was unlike any ever noticed before. Another inscription was afterward discovered at Aleppo by Mr. Davis, a missionary; and it also turns out that the famous figures sculptured above the roads from Ephesus to Phocea, and from Smyrna to Sardis, which are mentioned by Herodotus, and were supposed by him to represent the Egyptian King Rameses II, the Sesostris of the Greeks, have inscriptions upon them in the same character as that recently found in Carchemish, showing that these figures also are Hittite monuments. It is supposed that this language was the source of what is known as the Cypriote syllabary, found in Cyprus, a system of characters of which each does not, like the letters of the alphabet, represent a single sound, but a syllable, and which was probably the language in use among commercial people throughout Asia Minor, until it was superseded by the simpler and more practical Phœnician alphabet. This discovery is exceedingly interesting, as the Hittites belong to the same race of people who perfected, by the alphabet, that greatest of human inventions, a written language. We have now in this discovery of Mr. Smith the memorials of a lost people, in neighboring proximity to the Phœnicians; a people who had an important part in the early progress of ancient civilization, with respect to which an eminent Egyptian scholar expresses his conviction that future discoveries in the course of this exploration will afford convincing proofs that this civilization, which was of the highest antiquity, was of an importance which we can only guess at.

What may be anticipated when scholars are able to read these inscriptions, as in all probability they will be, for the cuneiform or arrow-headed characters of Assyria have been read, is foreshadowed by what has been brought to light by the discoveries of Layard and Smith in the mound which now represents what was once Nineveh. Beneath a mass of rubbish were found the remains of what had been a great Assyrian library, the materials of which being of baked clay had proved indestructible, and, though lying in broken fragments, Mr. G. Smith was able to piece the fragments together, and recover over three thousand inscriptions, forming pages of the volumes of which the library was composed, and in some cases recovering entire books. The tablets or leaves of these volumes or bricks, as they are called, are formed of thin plates of clay, upon either side of which the text was inscribed when the clay was soft, the tablet being afterward baked or dried, when the tablets or bricks, like our modern books, were arranged in chapters and volumes. Nearly two thirds of this library are now in the

British Museum, which, through the politeness of Mr. R. H. Major, I had the pleasure of inspecting in 1874. It embraces treatises on history, astronomy, geography, religion, morality, astrology, and other subjects. From one of these books, compiled after the manner of our modern encyclopædias, and the compilation of which is shown to have been made more than 2,000 years B. C., it has been ascertained, what has long been supposed, that Chaldea was the parent-land of astronomy; for it is found, from this compilation and from other bricks, that the Babylonians catalogued the stars, and distinguished and named the constellations; that they arranged the twelve constellations that form our present zodiac to show the course of the sun's path in the heavens; divided time into weeks, months, and years; that they divided the week, as we now have it, into seven days, six being days of labor and the seventh a day of rest, to which they gave a name from which we have derived our word "sabbath," and which day, as a day of rest from all labor of every kind, they observed as rigorously as the Jew or the Puritan. The motion of the heavenly bodies and the phenomena of the weather were noted down, and a connection, as I have before stated, detected, as M. de Perville claims to have discovered, between the weather and the changes of the moon. They invented the sun-dial to mark the movements of the heavenly bodies, the water-clock to measure time, and they speak in this work of the spots on the sun, a fact they could only have known by the aid of telescopes, which it is supposed they possessed, from observations that they have noted down of the rising of Venus and the fact that Layard found a crystal lens in the ruins of Nineveh. These "bricks" contain an account of the deluge, substantially the same as the narrative in the Bible, except that the names are different. They disclose that houses and land were then sold, leased, and mortgaged, that money was loaned at interest, and that the market-gardeners, to use an American phrase, "worked on shares"; that the farmer, when plowing with his oxen, beguiled his labor with short and homely songs, two of which have been found; and, to connect this very remote civilization with the usages of to-day, I may, in conclusion, refer to one of the bricks of this library, in the form of a notice, which is to the effect that visitors are requested to give to the librarian the number of the book they wish to consult, and that it will be brought to them; at the perusal of which one is disposed to fall back upon the exclamation of Solomon, that there is nothing new under the sun.

A very curious fact has come to light, resulting from Dr. Schliemann's discoveries in the Troad. In the lowest strata of his excavations at Hissarlik he found a vase with an inscription in an unknown language. Six years ago, the eminent Orientalist, E. Burnouf, declared the inscription to be in Chinese characters, for which he was generally laughed at at the time, from the improbability of Dr. Schliemann finding, in the lowest strata of his excavations, a vase with an inscription in the Chinese language. Now, however, it appears that the Chinese ambassador at Berlin, Li Fangpau, who in his own country is a distinguished scholar, has read and translated the inscription, which, he says, states that three pieces of linen gauze are packed in the vase for inspection, being what we, in our day, would call sending a sample of merchandise into a foreign country to create a demand for it. E. Burnouf previously declared that the inscription was to the effect that the vase contained pieces of goods (*pièces d'étoffe*). The Chinese ambassador fixes the date of the inscription as about 1,200 B. C., and further states that the unknown characters so frequently occurring on the terra-cotta are also in the Chinese language, which would show that, at this remote period, commercial intercourse existed between China and the eastern shores of Asia Minor and Greece.

There have been a number of discoveries throwing light upon the question of the antiquity of man. The latest conclusions upon this subject have been given by Dr. E. B. Tylor, President of the Anthropological Institute of England, one of the most eminent men in this field of inquiry. He states, as the result of the evidence so far obtained, that the causes which brought about the differences in the form of the skull, the color of the hair and skin, and the physical constitution of men, had chiefly accomplished their work long anterior to the dawn of history; since when, he says, some changes may be traced, brought about by migrations or the effects of climate. He declares that the ground taken by Principal Dawson, of Montreal, the eminent geologist, fixing the period of development at about 2,200 years B. C., is bringing it within the historic period, and that it has nothing, as shown by the Egyptian and Assyrian researches, to support it. Mr. Tylor states that the evidence now accumulated strengthens the probability that all men are descended from one original stock, which, he thinks, is inferable from the close resemblance of all human beings in body and mind, and from the freedom with which races intercross and produce mixed races. He thinks that the period anterior to history was one of vast length. He states that anthropologists now consider the Egyptians as belonging to an African rather than to an Asiatic race, as has been previously supposed. The reasonable conclusion, he thinks, is that they were a mixed race, but mainly of African origin, and that they came originally from the southern Somauli-Land, which, according to Egyptian tradition, was the place whence their gods were derived. His further conclusion is that the Chaldeans and Babylonians, as indicated by their early languages, the Accadian and Medic, were of a Tartar or Turanian family, and may possibly have belonged to the yellow races of China, while the Assyrians were of the white race; and he thinks that the conclusion of many naturalists is correct that the geographical center from which man emanated and spread over the globe was in the tropical regions of the Old World.

Dr. R. Fahn, on the contrary, who has been making extensive linguistic researches in South America, comes to a totally different conclusion from Mr. Tylor. The Doctor, in a communication published in Vienna, claims as the result of his researches that America is the Old World, and Europe, Africa, and Asia the New. He declares that the languages spoken by the Indians in Peru and Bolivia exhibit astounding affinities with the Shemitic languages, and especially with Arabic, with which the Doctor is thoroughly acquainted. He claims that the Shemitic roots are universally Aryan, and that the stems of all the varieties of the early Aryan tongues are found in their purest condition in the languages of the Indians of Peru and Bolivia, especially in the Quichua and the Aimara; and he maintains that the high plains of Bolivia and Peru are the central point from which the human race dispersed, which accords with the view expressed by some American archæologists that America is not only geologically but ethnologically the Old World.

Professor Mudge has gone into a calculation of the number of years to which the existence of man upon the globe may be traced, basing his calculation upon the rate at which the delta of the Mississippi is deposited. He reaches the conclusion that man has been on the earth not less than two hundred thousand years. Such computations, however, are, as Lyell has shown in respect to the deposits of the Nile, very uncertain data upon which to found any exact estimate of time.

The most important events in Arctic exploration have been the dispatching of the steamer Jeanette by James Gordon Bennett, and the accomplishing of the northwest passage around Asia by Professor Nordenskjöld.

The object of Professor Nordenskjöld's expedition was not only to accomplish what had been attempted so many times without success, but also the acquisition of important scientific information, it now being the opinion of meteorologists that the climate of Europe and America is materially affected by the ever-changing ice and other physical conditions of the Siberian seas; and that we shall never get a thorough understanding of the laws which regulate the movements of the winds, and the great currents of the sea, until we obtain a more thorough knowledge of the state of things in the polar basin.

The success of Professor Nordenskjöld in achieving this long-sought passage was due to the fact that he is himself an eminent scientific man; that he had a large experience previously in polar exploration, and that before undertaking this expedition he carefully studied everything that had been done, from the first attempt, in the reign of Elizabeth, down to the last expedition. He left Gothenburg on July 4, 1878, and arrived at Yokohama, Japan, on the 18th of the same month, a year later. Two hundred and sixty-four days of this time, the vessels were imprisoned in the ice off Cape Serdze, about one hundred and twenty miles from the Pacific termination of Behring Strait. The results arrived at by Professor Nordenskjöld are that the voyage from the Atlantic to the Pacific, around the north coast of Asia, may be made by a suitable steamer in a few weeks at the proper season, but that the route is not likely to be of any practical commercial importance; that there is no difficulty in establishing a regular communication by water between the rivers Obi and the Yenisei and Europe for the purposes of trade; that in all probability the voyage by sea between the Yenisei and Lena, and between the Lena and Europe, may be utilized for the purposes of trade; that the voyage there and therefrom may be made in the same summer; and that further explorations are necessary to determine whether a practicable communication by water can be established from the river Lena to the Pacific.

Geological and geographical work in the United States has been pushed with vigor, and some interesting results developed. Mr. G. K. Gilbert has surveyed the Henry Mountains of southern Utah, discovered by Professor Powell ten years ago, and has reached the conclusion that the Saskatchewan River, which rises in the Rocky Mountains, was formerly the upper course of the Mississippi, and flowed to the Gulf of Mexico, until, by the rising of the land in Minnesota, a barrier was created which changed the course of the river, and by which Lake Winnipeg came into existence.

Professor J. W. Powell has transmitted to the Government a report on the lands of the arid regions of the United States, west of the one-hundredth meridian and east of the Cascade Range, from which it appears that the abundant rainfall in the eastern portion of the United States diminishes westward, until at last an arid region is reached, in which agriculture is not possible without irrigation. This region, Professor Powell says, begins about midway in the great plains and extends across the Rocky Mountains to the Pacific Ocean, except that there is a greater precipitation of moisture in western Washington and Oregon, and the northwest corner of California, the winds impinging on this region being freighted with moisture, derived from the great Pacific currents, and where this water-laden atmosphere strikes the western coast in full force, as it does in the vicinity of the Columbia River, the precipitation is excessive, but rapidly decreases eastward to the summit of the Cascade Mountains, this humid area being designated by the Professor as the Lower Columbia region. The especially arid portion is the great Rocky mountain region of the United States, and embraces more than two-fifths of the whole country, excluding Alaska.

One of the curious results that surveys in this country have brought out is, that the configuration of a portion of central New York has been incorrectly described and mapped. Mr. J. T. Gardiner, who had charge of the survey, states that in nearly every instance places were misplaced one or two miles, while, in respect to the general features over which the survey extended, Mr. Gardiner says, "Colorado was not a greater surprise to me than has been the structure of my native

State," and that "the configuration of the country is as unique and as unknown to science as that of any part of the Rocky Mountains."

In South America a number of surveys have been made, one of the most notable being that of the São Francisco River, by W. Milnor Roberts, now chief of the Brazilian railways. It is, he says, a very peculiar river, thirteen hundred and two miles long from the ocean to the Falls of Perapora, and is one half wider than the Ohio at Cincinnati, with a large volume of water at the lowest stage of the river. Two hundred miles from its mouth are the great Falls of Paulo Affonso, with a higher elevation than the Falls of Niagara, though not like Niagara in one pitch. A railway is required seventy-five miles to connect the lower and upper rivers, which is now, he says, in the course of construction by the Brazilian Government. About two hundred and sixty miles of the river has many rapids, all of which he ascended, and after this there are, he says, about eight hundred miles of fair navigation for light steamers.

The geographical explorations in Asia, especially in the northern part of it and in the countries now under the control of the Russians, have been very extensive. One of the most interesting events in the East has been the visit of Mr. C. Doughty to the so-called rock city of El-Heggi, beyond Damascus, which, in the days of Ptolemy, was an emporium for trade in frankincense and gold. It is one of the seven fabled cities of the Arabs, which was said by them to have been hewed out of the surrounding mountains, and to have had one hundred funereal chambers excavated in the rock. Mr. Doughty reached the place with great difficulty, and found it to consist only of the remains of what appeared to have been four or five palm villages, each surrounded by a wall in the ordinary Arab manner. He discovered some sepulchral chambers, but they were very plain, with inscriptions cut in a panel over the doorways. This journey of Mr. Doughty has entirely dissipated the fabulous stories so long told about this place by Arab, Turkish and Persian pilgrims.

The work in China, Thibet, Corea, India, Japan, and throughout all parts of Africa, has been considerable. The Niger, after several unsuccessful attempts, has been traced to its source in the vicinity of a village called Konlako, near the frontier of Koronko. Lieutenant Savarin de Braza, after three years of very difficult exploration, has obtained a complete knowledge of the Ogowa River, which he has proved to be entirely distinct from the Congo, and to have no connection with any interior lakes.

The most remarkable of the recent explorations in Africa is that of the Portuguese explorer, Major A. A. de Serpa Pinto, in his journey from Benguela, on the western coast, across the African Continent to the Zambesi River, and thence in a southeasterly direction through the Matabeli kingdom and the Transvaal Republic to Natal on the Indian Ocean. He started from Benguela, on the west coast, November 12, 1877, and arrived at the end of his journey in Durban, on the Indian Ocean, on April 14, 1879, a journey occupying nearly twenty months. He discovered the source of the river Cubango, west of Bihé; and, shortly afterward, two of its affluents, finding the river to be contrary to all the descriptions of it on the maps. He says, in speaking of those affluents, "I use the words small rivers, but the smallest in Africa are almost always enormous ones." He found the river Cuqueima, to his surprise, running to the north, which was contrary to its position on the maps, and flowing from the north to the southwest, toward the Quango, of which it is an affluent. He afterward struck the Quango, flowing to the north, and the Cuito, an affluent of the Cuando, running to the south. All the great rivers, he says, of South Africa, have their sources in an immense rich plain, which is in 12° south latitude. The way in which rivers in this part of Africa take their rise and are formed, as described by him, is interesting. They begin with a slight humidity, resembling the trickling of a small fountain. By degrees the current swells, and suddenly, without having received any visible affluents, it becomes an enormous river, on which any one may sail with a boat. He says he saw the source of the Cuando, first as a tiny rill, which flowed between his feet; that a little lower down he descended it in a canoe, and that thence it was quite navigable till it entered the Zambesi, where Livingstone calls it the Chobe, a name which Major Pinto says is utterly unknown at the present day in Africa. Not only is the Cuando navigable, but also many of its affluents; and there is a cataract at its extremity, which nearly proved fatal to the explorer, as it had not been previously mentioned by any one. There is, he says, no connection by water between the Cuando and the Cubango, and while in the region of the Cuando he met one of the most curious discoveries in his journey. He found that one of the carriers supplied to him by a friendly chief was, to his astonishment, a white man belonging to a race in Africa heretofore entirely unknown. This race, called the Cassequer, he says, exist in large numbers in this part of South Africa, and that they are whiter even than the Caucasians, with this distinction, that, instead of hair, their heads are covered with small tufts of very short wool, that they have prominent cheek-bones, and eyes like the Chinese. He states that he has seen girls with such a complexion that, if their features were European, they would pass in Europe for beauties. Lieutenant de Braza is of the opinion that this race of people came from North Africa, as he states that he has seen a race greatly resembling them, called the Ubamlo, south of the Congo. The men of this white African race, Major Pinto says, are remarkably muscular and robust, and that when they discharge an arrow at an elephant they bury the entire shaft in the animal's body. They live by themselves, subsisting on roots or the spoils of the chase; and it is only when their supplies fall short that they hold any communications with their neighboring race, the Ambuelos, from whom they obtain food for ivory. He describes them as a nomadic people, never sleeping two nights in the same encampment; that they wander about in groups of from four to six families, over all the territory that lies between the Cuchi and the Cubango, and that they are the only people in Africa that do not cook their food, eating it raw. He makes the interesting statement, that it is the crossing of this people with the negroes that has produced, in his opinion, the race of mulattoes so well known in the lower part of South Africa by the name of Bushmen; a race who differ from those from which they have sprung, as they cook their food, and are of a good disposition, though quite opposed to civilization. He states that fevers prevail all along the river-banks of the Zambesi, and in the lands adjoining the river, but that the country extending inland from the highlands of Benguela is the most suitable territory in all tropical Africa for colonization, being five thousand feet above the sea, fertile, well watered, and healthy. The people, he says, are docile, capable of improvement, are very fond of dress, and that a market would here be found for the consumption of foreign manufactures.

DRESS IN RELATION TO HEALTH.*

By BENJAMIN WARD RICHARDSON.

THE character of the dress of a person stands so near to the character of the person who is the wearer of it that it is difficult to touch on one without introducing the other. All sorts of sympathies are evoked by dress. Political sympathies are in the most intimate of relationships with dress; social sympathies are indexed by it; artistic sympathies are of necessity a part of it. In a word, the dress is the outward and visible skin of the creature that carries it.

A charming and at the same time a very useful lecture might be written on the metaphysics of dress; but in this practical day, when the useful only is tolerated and the charming is considered superfluous—I mean, of course, in a lecture—I must let all attempt at such a combination fall to the ground. I must deal only with what is purely physical; the physical body and the physical stuff that is put on it—dress in relation to health.

In studying this subject I will consider the following topics:

Dress in relation to its mechanical adaptation to the body.

Dress in relation to season. I mean the amount of clothing that should be worn at different periods of the year according to seasonal changes, in this English climate.

* Lecture delivered at the London Institution on Monday, March 1, 1880.

Dress in respect to the admission of atmospheric air through it or beneath it to the surface of the body.

Dress in relation to the color of the material of which it is composed.

Dress in relation to the action of coloring substances which are introduced into its fabric and which come into contact with the surface of the body.

Cleanliness in dress.

These are all very serious subjects in respect to dress. If it were on the fashion of dress I had to treat, if I might have permission to lead you, as at a fancy-dress ball, through the historical domain of costume, then I might try to fascinate the most fastidious, and to make the time pass like a dream, in a promenade. Confined to health and dress, I can commit no ecstasy. I must be allowed to criticise, if not to scold, and rarely indeed to find one passing word that stands for commendation.

Let me, nevertheless, at once state that I have not a syllable of expression to bring forward against good fashion, and good changing fashion in dress. There is nothing whatever incompatible between good fashion and good health; they may always go well together, and they ought to go together. Naturally, I believe, they would always go together, because they are both good, and two goods can never make a bad. In like manner, bad fashion in dress and bad health go together very often, because two bads can not make a good. For my part, I have never seen a good fashion of dress that was not a healthy fashion, and the world has only been led astray on this matter by the unfortunate circumstance that it has allowed its taste to be directed by the childishness of ignorance. In early times costume, naturally enough, sprang out of innocence. Scientific rules were unknown, and, if we may take the history of primitive nations as true, artistic rules were not supremely developed or carried out. Through long ages fashions varied, mainly on the artistic side, approaching only toward scientific necessity in cases where arctic cold or tropical heat enforced some kind of consideration for the person who had to be clothed. Later in more modern and scientific times, fashion has been governed by the most superficial, vain, and imprudent of so-called artistes and fashion-leaders, who have invented modes out of their own little heads, and have set Nature at defiance, as if they were Nature, and she were an idiot—thereby changing places with her in the most complacent manner.

Let me say further even than this: I commend good fashion and fine, nay exquisite, taste in dress as a good thing of itself, independently of health. I agree entirely with Mrs. Haweis that it is the bounden duty of every woman to make herself look as handsome as ever she can. If she have natural beauty, she ought to study how to maintain it in and through every period of her life—yes—to the last;

for there is nothing more beautiful than beauty in old age. If she have moderate beauty, she should do her utmost to make the best of it. If she have no beauty, she ought to impart all that is possibly near to it by every kind of justifiable supplement. If she be positively ugly, the more is it her duty to use every legitimate art to hide the fact, and to transform even ugliness into passable presentation. Look at an ugly woman badly attired, and showing all the lines that offend taste. Look at the same woman gracefully attired and fairly, artistically gotten up, with some approach toward the beautiful, and who would hesitate to pronounce in favor of a longer *tête-à-tête* with the last of that woman as compared with the first? Why! we blockheads of men are sometimes entirely taken in by skillful, ugly women. We look upon them as handsome. The deception is justifiable, and our satisfaction is more than a recompense for our stupidity.

What is good for women is not worse for men, but I am sorry to say that men are far behind women in their endeavors to assume the beautiful. In my time I have never, off the stage, seen a man dressed many removes from the hideous. When I first began to look at my male seniors, universal black was the rage, black from head to foot; the very head, which was the only part of the animal that emerged out of darkness, rising from a broad black ring called a stock, into which the chin sometimes dropped. A little later, and an extremely tight mode of dress came into fashion, a mode which is not yet entirely discarded, but which still fits closely to those strangely occupied individuals called "copers," about whom there is a mystery as to whether their clothes were not originally and permanently modeled to their bodies. Recently there has been some attempt at improvement in English male attire. The surtout-coat, rather loosely fitting, and cut so as to hang well from the shoulders, has imported a modest but good change in fashion, while the looser and better-shaped nether habiliments have so improved in design that even the sculptors have, at last, with much compunction of conscience, ventured to reproduce them in marble.

Still, in the attire of men, and I think I must say in the attire of women also, a great deal is wanting in taste, and the most bigoted Darwinian would hardly, I think, dare to declare the doctrine of "the survival of the fittest" in respect of modern clothes, whatever he might say of the wearers of them.

I name these points that I may not be accused of feeling no care for the fashion connected with dress. I would have good fashion go with every hygienic improvement in clothes and clothing, and I know it would be easy to prove that hygiene of dress could always be combined with the most artistic and perfect of fashionable designings, by which combination health, comfort, and elegance would all be insured.

Such combination set forth as a national fashion should pass, as I think, through all classes of the community; for, assuredly, even at this time, though it be better than it once was, few things designate classes and keep up distinctions of classes so much as the clothes that are worn, the badges, I had almost said, of the wearers. The costumes of the trim shopman, the slovenly mechanic, the country laborer, the flourishing squire, the tight-laced soldier, the club exquisite, the lugubrious doctor, the devil-may-care artist, and the awful ecclesiastic in his demented hat and sacred pinafore—these costumes and others betray a want of national taste and national unity which I for one, health-seeker as I would be, utterly repudiate. There can be no amalgamation of mind and heart while these distinctive outside declarations exist among us. In robes of office, during periods of office, men may well be distinctively clad. On the bench, at the bar, in the pulpit, in the professor's chair, such costumes are classically graceful and usefully distinctive, while in the workshop or other place of business a particular outer dress suited to the occupation is no doubt necessary; but for ordinary intercourse something in common in the way of dress were surely, in these advanced days, the thing to cultivate.

I pass now to the first head of my subject proper: Dress in relation to its mechanical adaptation to the body.

I. The first and most serious mechanical error committed on the body by dress is that of tightness, by which pressure is brought to bear upon some particular part. Presuming that an equable general pressure, not extreme in its character, and including the whole body, were applied for fitting purposes, that is to say, for the purpose of indicating outline, no great evil probably would follow from the application of such pressure, provided that it were so adapted as to give with the growth, to yield a certain measure of elasticity, and to permit perfect freedom of motion. A little more, perhaps, may be admitted even than this. In advanced life, when the shape of the body becomes irregular, and when the weight of those parts drags on the rest of the body, clothing specially adapted to those parts, and surrounding them with close and even pressure, gives useful and effective support, adding greatly at the same time, it may be, to the appearance of the body. These are exceptional conditions requiring exceptional management.

That kind of pressure to which objection must be most determinately taken is where the pressure is used, not for giving support to the body, nor for sustaining natural outline, but for the express purpose of producing an entirely artificial shape and outline. It is astonishing how resolutely the advanced professors of medicine, in all times in which they have written, have denounced the practice of compressing the body in the stages of its growth for the purpose of molding it into some unnatural form incident to fashion. It is equally astonishing to find how resolutely the votaries of the fashion have resisted the teachings of the learned, who may be said never to have made a single point in advance toward a practical victory. Now and then fashion has given way for a short time, but it seems always to have fallen back again and resumed its place.

For my part, I can do no more than earnestly follow my predecessors and compeers in their crusade against this foolish practice, and especially against it as it affects the female part of the community. The corset and the waist-belt I must once more condemn as opposed to all that is healthful and all that is beautiful. By these appliances, through which an unequal pressure is exerted on one part of the body, the functions of the lungs, of the heart, and of the digestive organs are all kept under imperfect condition. The breathing is suppressed, the heart-beat is suppressed, the digestive power is suppressed. In this way the tripod of life—for life rests on the digestion, the respiration, and circulation—is made imperfect, and with that imperfection every other part of the body sympathizes. Of late years women have raised the cry, and I think quite properly, that they are too much subjected to the will of men, that they have not the privileges which should belong to them as fellow human beings. But, in fact, no subjection to which they have ever submitted can be greater than this to which they have subjected themselves, and I would venture to say that, while they continue this self-infliction, they can never, under any improved system of social freedom, experience the benefit of the change. If, to-morrow, women were placed in all respects on an equality with men, if they were permitted to sit in Parliament, enter the jury-box, or ascend the Bench itself, they would remain under subjection to superior mental and physical force so long as they crippled their physical, vital, and mental constitutions by this one practice of cultivating, under an atrocious view of what is beautiful, a form of body which is destructive of development of body, which reduces physical power, and which thereby deadens mental capability.

Of the two evil practices to which I refer, the tight waist-belt is, I think, worse than the tight corset, except where the corset is so adapted that it acts at one and the same time as belt and compressor general. The effect of either is to press down upon the liver and stomach, to prevent the free circulation of blood through these organs, to diminish their active physiological function, to make them descend and compress the vital organs that lie beneath them, and so to impair the growth and action of all the great secreting structures. The effect, again, is to interfere with the great breathing-muscle, the diaphragm or midriff, which divides the chest from the abdomen, and which, by its descent, causes the lungs to fill in breathing. Lastly, the effect is to press upward, and so to interfere with the heart and lungs themselves. An eminent Parisian physician, M. Breschet, recorded many years ago the facts relating to a woman who, on the right side of her throat, had a swelling which reached from the collar-bone to the level of the thyroid cartilage, and which, when the chest was tightly laced in corsets, was enlarged to its fullest. In this swelling the murmur of respiration could be heard when a stethoscope was applied over it; but, when the chest was set at liberty and the swelling was gently pressed downward, it disappeared. In this instance, a portion of the right lung had actually been forced behind the collar-bone, out of the cavity of the chest altogether, into the loose tissue of the neck.

This was a very exceptional experience, no doubt—one I have not myself seen nor found record of in this country. At the same time, I have seen very close approaches to it. I have several times known the lungs to be pushed quite out of place and compressed toward the upper part of the thorax, and I have known the heart extremely displaced by the same pressure.

That which mothers and the guardians of youth ought to know is, not only the fact of displacement of organs under pressure, not only the fact of the temporary derangement of the function of the organs, but the further and more important fact of all, as affecting the future life of the person most concerned, that under the pressure the organs implicated can not grow so as to attain their full and complete development within the period that marks the outline of growth. It is impossible, therefore, that those who are imprisoned in growth can attain full development of body. The folly they pay for in youth extends through middle age, and expedites the decline.

The evils arising from compression of the chest, as above mentioned, are not confined altogether to the female sex. They are brought about in boys and in men. It often becomes a habit in schools and colleges for youths to employ a strap or other form of belt for holding up their trousers; one boy sets the example, and the others think it right to follow; so the practice becomes general, and you find a tight line indicating pressure marked round the bodies of these youths. Fortunately, in their case, as they emerge into life, and before great mischief is done, they give up the strap and take to supporting the clothes from the shoulders, by the brace, and so they escape further injury; but while it lasted the injury undoubtedly was severe.

There is another and more permanent injury of this kind, however, carried out by boys, even by men, which consists in wearing a belt for the purpose of giving what is called support. Boys who are about to run in races, or to leap, put on the belt and strap it tightly, in order, as they say, to hold in their wind or breath. Workingmen who are about to lift weights or carry heavy burdens put on a belt for the same purpose, their declaration being that it gives support. Actually there is not a figment of truth in this belief. It is the expression of a fashion, and nothing more. The belt impedes respiration, compresses the abdominal muscles, compresses the muscles of the back, subjecting them to unnecessary friction, and actually impedes motion. No boy would think of putting a belt tightly round the body of his pony if he wished it to win a race or to leap a hurdle; no workingman would put a belt tightly round the body of a horse to make it pull with greater facility a load which it was drawing. On themselves they commence the practice, because somebody has set the example; then they get accustomed to the impediment, and think they can not get on without it. Drinking is learned by just the same absurd process.

I had a workingman once in my employ who would undertake no vigorous effort until he had tightened his belt. Once I got him to test what he could lift with and without the belt, and he was obliged himself to admit that he could do more without it than with it; but, he argued, he could not get on without it. That is what ladies say about corsets.

Respecting this belt for boys and men, there is a word more I must say which is of serious import. When they put on the belt for the sake of performing some feat of strength, they effect another dangerous mischief. Compressing the abdomen, they force, during the exertion, the contents of the abdominal cavity downward under pressure, giving no chance to resilience back again after the exertion or shock. In this way they frequently cause hernia or rupture. I have seen, professionally, several instances of this occurrence in boys, and among workmen who wear belts this accidental disease is so common that it is the rule rather than the exception to find it present.

Other forms of tight pressure upon the body are open to serious if not to equal objection. The wearing of shoes which compress and distort the feet is a singularly injurious custom. Suppose I said that nine tenths of the feet of the members of an English community were rendered misshapen by the boots and shoes worn, the statement would seem extreme, but it would be within the truth. The pointed shoe or boot is the most signal instance of a mischievous instrument designed for the torture of feet. In this shoe the great-toe is forced out of its natural line toward the other toes, giving a reverse curve from what is natural to the terminal part of the inner side of the foot, while all the other toes are compressed together toward the great-toe, the whole producing a wedge-like form of foot which is altogether apart from the natural. Such a foot has lost its expanse of tread; such a foot has lost its elastic resistance; such a foot has lost the strength of its arch to a very considerable degree; such a foot, by the irregular and unusual pressure on certain points of its surface, has become hard at those points, and is easily affected with corns and bunions. Lastly, such a foot becomes badly nourished, and the pressure exerted upon it interferes with its circulation and nutrition. It ceases to be an instrument upon which the body can sustain itself with grace and with easiness of movement, even in early life; while in mature life and in old age it becomes a foot which is absolutely unsafe, and which causes much of that irregular, hobbling tread which often renders so peculiar the gait of persons who have passed their meridian.

It sometimes happens for a time that these mistakes in regard to the boot and shoe are increased by the plan of raising the heel and letting it rest on a raised impediment of a pointed shape. Anything more barbarous can scarcely be conceived. By this means the body, which should naturally be balanced on a most beautiful arch, is placed on an inclined plane, and is only prevented from falling forward by the action of the muscles which counterbalance the mechanical error. But all this is at the expense of lost muscular effort along the whole line of the muscular track, from the heels actually to the back of the head—a loss of force which is absolutely useless, and, as I have known in several cases, exhausting and painful. In addition to these evils arising from the pointed heeled boot, there are yet two more. In the first place, the elastic spring of the arch being broken by the heel, the vibration produced by its contact with the earth, at every step, causes a concussion which extends along the whole of the spinal column, and is sometimes very acutely felt. In the second place, the expanse of the foot being limited, the seizure of the earth by the foot is incomplete both in standing and in walking, so that it becomes a new art to learn how to stand erect or to walk with safety.

Another form of constriction in dress is that produced by the garter. By this pressure a line of depression is often produced quite round the limb below the knee, and the course of blood through the veins from the foot and leg, into the body, is seriously impeded. This is one cause of varicose veins, sometimes an original cause, and always a serious impediment to recovery when, from any other reason, the enlarged or varicose vein is already present. The ligature or band called the garter is bad in any way, but is far worse when it is worn below than above the knee, for above the knee the two tendons, commonly called ham-strings, receive the pressure of a great portion of the bandage, and act as bridges to the veins which pass beneath.

In men I have seen mischief from the tight cravat and collar, the pressure caused by the same leading to an obstruction to the due return of the blood from the brain. This, in persons of plethoric habits especially, is a danger not to be disregarded, and, though it may be of comparatively rare occurrence, it is worth mentioning. I have more than once in my life had occasion to see the injurious results produced by it.

I have now referred to the four varieties of pressure which are the most injurious in dress: pressure at the waist; pressure at the foot; pressure round the leg; and pressure round the neck. I place them in the order of their importance, but the first undoubtedly outweighs the others altogether.

It is actually impossible to overstate the physical injuries which result from these mistakes in bodily attire. I have told some of them. I reserve one which I will state before I pass to a new section. It will, perhaps, influence some who are comparatively thoughtless on this subject; it will, I am sure, influence all sensible and thoughtful people. It is this observation, that the mischiefs inflicted by mode of dress become hereditary in character. I do not mean to say that, because a person produces in himself or herself a deformed waist or foot, by dress, therefore that particular deformity will be physically hereditary in the offspring of such person. I think the evidence is rather against that view, because it would seem that the Chinese children, born of mothers whose feet have been mechanically distorted, are born with feet which would come to a natural condition if they were not bandaged in infancy in the same manner as the mothers' were. But of this I am sure, that the hereditary tendency to commit these deforming acts is hereditarily received and hereditarily transmitted, and that the sense of desire for the performance of the act is also transmissible. This, in fact, is one of the great difficulties which we teachers have to overcome. We have to fight against inbred proclivities, which are so deep rooted that I believe if all the women of England at this time could, by a voluntary act of education, be led to give up tight lacing, another generation, perhaps two generations, would have to live before the practice was entirely abolished.

The lesson we have to learn and practice in respect to the mechanical arrangements of dress so far is, that every plan which leads to irregular tightening of the body should be given up. The corset and waist-strap should especially be abandoned, and our young girls should be taught to grow up just as their brothers grow, without ever learning the sense of false support which the corset soon suggests as a necessity. With the members of both sexes a reform should be introduced in the matter of boots and shoes. The tight boot should be entirely discarded, and that boot preferred which approaches nearest in form to the natural foot. Mrs. Haweis and others have insisted on the removal of the raised heel altogether from the boot, with which I entirely agree. Anatomically and physiologically it is a complete mistake to have the heel raised from the ground beyond the level of the palm of the foot. The moment the heel is raised, the plan of the arch is deranged, and the elastic, wave-like motion of the foot impeded. The arch ought always to have full play, and Mr. Dowie's plan of introducing an elastic connection or band across the arch, so as to allow it freedom, is an admirable device.

The method by which clothes should be supported on the body is another extremely important subject in connection with dress, and especially in relation to the dresses worn by women. Copying probably from an Eastern custom, and from the primitive method of wearing a girdle, it has become a habit endorsed by long centuries of use for women to carry all their long, flowing robes from the waist. These, tied one over the other, layer upon layer, and with sufficient tightness to enable the garments to be borne by the actual pressure upon the waist, are as great an incumbrance to the wearer as the corset. Indeed, it is sometimes argued that the corset is necessary, in order that the pressure may be sustained, the corset itself acting as a kind of shield between the body and the bands, and acting also in some way like a shoulder for supporting the bands. When the dresses which are thus sustained are short and of light texture, the weight and incumbrance are considerable; but when the dresses are long, when they trail on the ground, and when they are made of heavy material, the weight and incumbrance are drags on the life, which I suspect the strongest man could not sustain while engaged in his ordinary avocations.

I am rejoiced to see that ladies themselves, who are writing intelligently on this topic, are earnestly teaching in respect to it what is both common sense and common humanity. I agree with these that the tax of carrying clothes from the waist is utterly unjustifiable, and that the parts that should bear the burden are the shoulders and none other. In this regard women ought to be placed under just the same favorable conditions for movement of the body as men, and the greatest emancipation that woman will ever have achieved will have arrived when she has discovered and carried out this practical improvement.

In saying this I do not for a moment wish to suggest that the outward appearance of the feminine dress should be like that of the masculine dress. To the woman, the flowing robe which even trespasses a little on the ground is most graceful, and is signally characteristic of feminine beauty. I would, therefore, that it should remain in all its gracefulness, but in so far as everything else is concerned, for every circumstance in which health is involved, for warmth, for freedom of movement, for mode by which the dress is carried from the shoulders, I would say, Let the women have all the advantages which now belong to men.

For any one who will for a moment think candidly must admit that the dress of men, however bad it may be in taste, or in whatever bad taste it may have been conceived, is, in respect to health, infinitely superior to that of women. In the dress of the man every part of the body is equally covered. The middle of the body is not enveloped in a number of close layers, while the lower limbs are left without close clothing altogether. The center of the body is not strained with a weight which almost drags down the lower limbs and back. The chest is not exposed to every wind that blows, and the feet are not bewildered with heavy garments which they have to kick forward or drag from behind with every advancing step. The body is clothed equally. The clothing is borne by the shoulders; it gives free motion to breathing; it gives freedom of motion to the circulation; it makes no undue pressure on the digestive organs; it leaves the limbs free; it is easily put on and off; and it allows of ready change in vicissitudes of weather. These are the advantages of modern attire for the man, and all I claim is that they should, by faithful copy, be extended to the woman, with the one exception of the graceful outer gown or robe, as a supplement to her own superior grace and beauty.

It is told of the late eminent surgeon Mr. Cline, the teacher of Sir Astley Cooper, that when he was consulted by a lady on the question how she should prevent a girl from growing up misshapened, he replied, "Let her have no stays, and let her run about like the boys." I gladly reëcho this wise advice of the great surgeon; and I would venture to add to it another suggestion. I would say to the mothers of England: Let your girls dress just like your boys, make no difference whatever in respect to them—give them knickerbockers, if you like—with these exceptions, that the under-garments be of a little lighter material, and that they be supplemented by an outer gown or robe which shall take the place of the outer coat of the boys, and shall make them look distinctively what they are—girls clothed *cap-à-pie*, and *well* clothed from head to foot.

In speaking of these mechanical arrangements of dress I have as yet made no mention of the throat and the head as parts requiring to be clothed. In suggesting that girls should be clothed as fully as boys, I have incidentally conveyed that the chest of the girl should be covered, and I would add that in both sexes the throat should be covered also during the period extending from October to April. The throat is one of the most important parts to protect, and it is, as is well known, one of the most common parts of the body to become affected during cold weather. In this past bad weather it has been my constant—I had nearly said, daily—observation to see some affection of the throat, attended with cold, and so often has this occurred in those whose throats have been uncovered as compared with those who have used careful moderate covering, that I can not doubt that the absence of such coverings has had, and has, a very deleterious effect.

Of coverings for the head I should say that they should be always light and free, whether a bonnet, or a cap, or a hat be the subject under dispute. I think the gypsy hat beats the Quaker bonnet for the fairer sex; and, although for men I can not say anything in favor of the tall chimney-pot that will redeem it from its ugliness, I must claim for it that, when it is light and well ventilated, it is healthy. The felt hats are too closely fitting, though some are becoming. The stiff felt hat, with narrow, turned-up brim, and which looks like a Roundhead's helmet without the metal, is in respect to health miserable, and in respect to appearance simply hideous. The most graceful of all head-dresses for either sex—and it suits either—is the fine old Geneva cap, sometimes called the "Leonardo da Vinci," which I wear on occasions, by right, as the doctor's cap of the old University of St. Andrews. It is not merely a handsome head-dress, it is healthy also, and adapts itself to heat and cold. I, for one, would willingly give up the particular privilege of wearing it, to see it more widely adopted.

II. From the subject of mechanical adaptations of dress I pass to consider dress in relation to season; the amount and kind of clothing that should be worn at different periods of the year.

On this subject there is great contrariety of opinion, and perhaps still greater contrariety of practice. There are those who maintain that to be healthy the body should be hardened by exposure to cold, and that to wrap up and coddle is the weakest and worst of all plans. It must be admitted that there are some persons who seem to flourish under this *régime*, and who live to advanced age without suffering from cold even when lightly clad. I have known myself three men who have approached their ninetieth year, and who always vigorously refused to wrap up at all. Such persons are great examples, but they are too exceptional to be counted as safe ones. The majority of the aged die, as a rule, rapidly during the cold weather. I have known children that have lived through their childhood half clothed in coldest seasons; and these are great examples, but they also are too exceptional to be accepted as safe examples. As a rule, ill-clad children in cold weather suffer intensely, and often die.

On the other hand, no doubt, some persons do greatly over-encumber themselves with clothes; and it is curious to observe that stout persons, who are wrapped and thoroughly lapped in their own subcutaneous non-conducting layer of fat, and who are generally feeble, encumber themselves with more clothes than their lithe and spare-ribbed friends, who really require most protection.

The truth is, that extremes on both sides are bad, and that a dash of good common sense is required to equalize them.

In this climate the regulation of dress in relation to health is an actual necessity during the varied seasons that prevail. We may take it as a general rule that, when the body requires more food and more sleep to meet the cold, it requires also more clothes than it does at times when sleep and food are also less wanted. There is a very remarkable physiological truth bearing on this point which every one ought to know, inasmuch as a knowledge of it becomes a guide to us in our daily life, not only in relation to dress, but to food, exercise, labor, and repose. The truth is so practical that I dwell upon it with some detail. It is this: There are certain periods of the year, in this climate, during which, independently of our wills or our actions, we are gaining in bodily weight, while there are other periods when we are losing, both periods showing a regularity which is as singularly correct as it is singularly interesting. This truth was first discovered by my late friend Mr. W. R. Milner, for many years medical superintendent of the large prison at Wakefield. His discovery was elicited by the laborious process of weighing, daily, immense numbers of prisoners through various seasons for a long series of years. I give his results as he himself has stated them.

The prisoners were all males between the ages of sixteen and fifty, and were presumed to be in good health when sent. The cells in which they were confined had a cubic capacity of about nine hundred feet, and from thirty to thirty-five cubic feet of air were passed through each cell per minute. The mean temperature of the cells for the entire year was 61°; the highest monthly mean, 66·5°, occurred in August; the lowest, 56·9°, in March.

The diet was uniform, with the exception of the alterations ordered by the medical officer in individual cases, and consisted of the following articles daily: Bread, twenty ounces; meat without bone, four ounces; soup, half a pint—these are equivalent to about seven ounces and three quarters of butcher's meat—potatoes, one pound; skimmed milk three quarters of a pint; gruel, one pint, containing two ounces of oatmeal. The dress was, a cloth jacket, waistcoat, and trousers; cap and stock; linen shirt; woolen stockings, drawers, and under-shirt.

The prisoners were sent out to exercise in the open air nine hours a week; the exercise was for one hour at a time; the men walked in circles, and every ten minutes they ran for a hundred and fifty yards. They were all supplied with work, and were for the most part employed in making mats and matting of cocoa-fiber and other materials; some worked at tailoring and shoemaking, and a few had other work to perform.

All the prisoners were weighed on admission, and at the latter end of every calendar month during their stay.

The number of prisoners over whom these observations extended was four thousand; the period of time occupied, ten years; the average number weighed monthly, three hundred and seventy-two; and the total number of weighings, forty-four thousand and four.

The men had all been weighed by Mr. Milner or under his superintendence, and the series of observations was unbroken.

The results of these weighings were tabulated on various bases, with a view to isolate the effect of a certain number of variable on the gain or loss of weight among these prisoners, and to determine the amount of influence exerted by each of these conditions.

The conditions selected for investigation were:

1. The season of the year.
2. The period of imprisonment.
3. The employment in prison.
4. The age of the prisoners on admission.
5. The height of prisoners on admission.

The influence exerted by each of these conditions was well marked, and, with one exception, viz., the influence of season, the deductions were such as would have been anticipated.

The first showed the influence of the season of the year on the weight of a number of men placed during the entire year under circumstances of food, clothing, and work which did not differ, and who, for the greater part of the day, were in a temperature which did not vary greatly between the hottest and the coldest months. Under such circumstances it might be expected that the weight of the men, taken as a whole, would remain sensibly the same; and that the numbers losing or gaining, as well as the quantities lost or gained, would vary little month by month; or that, if any marked variation occurred, it would be of an accidental character, depending on the greater or less amount of sickness during any particular month. The results, however, showed that a marked periodicity existed, and that, taking an average of years, there were two distinct series of months, during the one of which there was a constant loss of weight, and during the other a constant gain, so that, if the year were divided into quarters, there was a loss during the first and fourth quarters, and a gain during the second and third.

The two series of gaining and losing months were unbroken, except in one instance. On reference to the results it was found that in November, which was in the losing series, a gain occurred. The amount gained was very small, and the discrepancy was caused by the arrival of large numbers of prisoners in September and October, who usually gained weight for a short time after they were received, so that probably this break in the series resulted from the influence of the stage of imprisonment, which rather more than balanced the influence of season. On estimating carefully the facts which showed the average gain or loss per prisoner weighed, it was seen that, beginning at December, the amount lost per man increased rapidly and very steadily till March, but that between March and April there was a very abrupt transition from loss to gain. The gains then continued till August, the amount gained increasing on the whole, by a series of jerks, each alternate month presenting a larger and a smaller gain respectively: so that, to obtain a steadily increasing series, it was necessary to couple the summer months in pairs. Between August and September a change of weight occurred, about equal in amount, but in the opposite direction to that which took place between March and April. The changes between March–April and August–September were far greater in amount than the changes which took place between any other pairs of consecutive months; and this remark applied with greater force to the percentages of men gaining or losing, and to the net gains and losses per man.

The inferences which may be fairly drawn from these observations were: 1. The body becomes heavier during the summer months, and the gain varies in an increasing ratio. 2. The body becomes lighter during the winter months, and the loss varies in an increasing ratio. 3. The changes from gain to loss, and the reverse, are abrupt, and take place about the end of March and the beginning of September.

The results, which were thus gathered from the study of a large number of periodical weighings, presented a remarkable relation to the facts obtained by Dr. Edward Smith from a series of most valuable and elaborate experiments which he made on the quantities of carbonic acid thrown off by the lungs at various seasons of the year. For instance, Dr. Smith found that the quantity of carbonic acid thrown off was much greater in winter than in summer. Milner's weighings showed that the prisoners lost weight in winter, when the evolution of carbonic gas was great, and gained weight in summer, when less carbonic acid was given out.

This in itself would be a striking coincidence; but it was clearly detected that a sudden change took place between March and April, and at the same time of the year Dr. Smith found that a similar change took place in the amount of carbonic acid thrown off, and that the *amount* of the change was much greater at that period than at any other time; and so much greater that the alteration struck him as being a very remarkable circumstance. Dr. Smith's observations did not extend to the August–September period, and it is, therefore, impossible to say if any equally marked change takes place in autumn. There can be little doubt that variations of temperature and of light are the principal agents in causing these changes; but it will probably be found that, in addition to the direct influence of these physical agents, a periodic action in the system adds to or diminishes the effect of those physical agencies.

From the consideration of the facts collected we may fairly infer that there is a periodic variation in the weight of man during the year, the six summer months being gaining and the six winter months being losing months. The amounts gained or lost gradually increase from the commencement till the termination of each period respectively; the change from the gaining to the losing period and the converse is, however, abrupt, and these changes take place at times not very distant from the vernal and autumnal equinoxes.

Bearing on the question thus raised by Mr. Milner, I myself, from the Registrar-General's returns, made an analysis of 139,318 deaths, occurring, from 1838 to 1853, in London, Devonshire, and Cornwall, with a view of determining what causes of death were connected with the varying seasons of the year; and the result was to discover that during the wasting season, which was by far the most fatal, those diseases were most rife which spring from exposure to cold, and which are extremely fatal under that condition. I have since then many times drawn special attention to the importance of regulating clothing so as to meet the emergency to which the body is exposed during the wasting period; and the rules I had then in my mind I would enforce now. It should be a settled practice with every person in these islands that he commence to put on warmer clothing a little before the wasting period begins, and that he continue it considerably beyond the time when the balance turns and the period of increasing weight commences.

Bearing still further on this point, I have received a most practical note from the Rev. B. A. Irving, M. A., head master of the college, Windermere, in which the argument set forth above is fully confirmed. Mr. Irving indicates, from meteorological data, that about the 10th of May and about the 10th of November there is a remarkable fall in the mean temperature. The fall, commencing in November, continues to increase until the end of February. The pinch of cold in May is followed by warmth, which continues through the summer. The rule Mr. Irving deduces from these physical facts is, that we should be warmest clothed from the end of January to the end of February, and that summer clothing should on no account be assumed until the cold pinch about the 10th of May is well passed—say about the 15th of May. The summer dress may then be continued until the end of September; but winter clothing should be most carefully assumed before the cold pinch of November 10th—say by the 1st of November. With this sound advice I entirely agree.

Need I hesitate to say how dangerously these simple rules are ignored, and that, too, by those to whom it most solemnly applies! The delicate girl invited to the ball or evening party, in the winter season, goes there with a throat and chest exposed or partly covered, and with all her garments as light as fashion will permit them. She goes into a close room, heated to 65° or it may be 70°. She dances herself into a glow, and then, exhausted, excited, and breathless, she passes out of the room, to exchange its warmth for a temperature of 35°, or lower—perhaps below freezing-point. She takes cold, she suffers from congestion of the lungs, and, if her tendencies are in that direction, she passes into consumption. And who shall wonder?

As spring advances, dangers increase to everybody. The weather is treacherous; a bright day or two in March seems to herald summer, and the warm clothing is cast aside. Suddenly, there is a fall of temperature with a bitter east wind, and the unprepared are caught as if in a trap. They have passed the long wintry ordeal before which so many have succumbed, and they are reviving, but have not revived. In this condition they are stricken with disease, often fatal. If you study the Registrar-General's returns through the months of March, April, and the early part of May for a few years, you will see how solemnly correct is the history I am now bringing under your notice.

You will ask, What kind of clothing is best to meet the varying changes? I answer, That which combines lightness with warmth, and which absorbs the watery secretion from the body without retaining it. For underclothing I give a decided preference to silk, basing this preference entirely on practical grounds. Knitted or woven silk is at once the material which best maintains warmth, affords lightness, and transmits perspiration. If the expense of it be urged on one side, its extraordinary durability may be named as a set-off. The silk should be worn next to the skin. Over the silk, for nine months in the year at least, there should be a woolen covering which should include the whole body. This should not be made of thick, heavy flannel, for thickness and weight contribute little to warmth, but of soft, light, fleecy material, or of that thin flannel which somewhat resembles silk in structure. The feet coverings should be of the same character, and long socks should be preferred to stockings. The upper clothing, like the under, should be of light and, at the same time, warm character, and the final overcoat or cloak should carefully vary with the season. In coldest weather fur is, I think, without doubt, the best external clothing. The overcoat or cloak should, in all cases, fit loosely to the body.

III. Connected with this part of my discourse, there comes in naturally the ventilation of clothes on the body to which I referred in the opening paragraphs. I can not too seriously express the necessity of maintaining a free ventilation. Whatever impedes the evaporation of water from the body leads, of necessity, to some derangement of the body, if not to disease ; for the retained moisture, saturating the garments, produces chilliness of surface, and checks the action of the skin. Then follow cold, dyspepsia, and, in those who are disposed to it, rheumatism. For these reasons I always hold that the so-called waterproofs are sources of great danger, unless they are used with great discrimination. It is true they keep the body dry in wet weather, but they wet it through from its own rain ; and when the body is freely exercised and perspires copiously during rain, shut up with its own secretion on one side of the waterproof covering, and chilled by the water that falls on the other, it is in a poor plight indeed. It had better be wet to the skin in a porous clothing. Hence, I would advise that the waterproof should only be used when the body is at rest, as when standing or sitting in the rain. During active exercise a good, large, strong umbrella—none of your finikin parasol-like pretenses—is worth any number of waterproofs.

IV. The color of the dress is another practical point of considerable moment. The "Lancet," a few weeks ago, was very much criticised for suggesting that in the cold, dark weather dresses of light color should be worn. The "Lancet," nevertheless, was right. The light-colored dress is at once the warmest and the healthiest. In the Arctic regions white is the prevailing color of the animal that most retains its warmth. The same color is also best adapted for summer wear, for that which is negative to cold does not absorb heat. The objection made to white clothing is, that it so soon becomes dirty, or, correctly speaking, that it more quickly than darker fabrics shows the presence of dirt. This might be an advantage in many cases, but I think it is fair to admit that white out and out, for all times and seasons, is not practical. The best compromise is a gray, and I wonder that in our climate that practical fact, which was once known and acted upon, has ever been allowed to die out. Those wise and discerning forefathers of ours, who utilized the serviceable gray suits, were best informed, after all, in the matter of color of dress, for health as well as for service.

Fashion, in these later times, has misled once more, by the introduction of the incorrigible black clothing for the outer suit of men and women. The inconvenience of this selection reaches its height in the infliction it imposes on those poor ladies who, after bereavement, think it necessary to clothe themselves in unwholesome folds of inky crape. Next to the suttee, this seems to me the most painful of miseries inflicted on the miserable. Happily, it is, I think, beginning to see its last days.

V. I would make, in one or two sentences, an observation on the coloring substances that are sometimes introduced into dress, in their relation to health. When the aniline color stuffs were brought in for dyeing under-garments of red or yellow color, the dyes caused, sometimes, where they came into contact with the skin, a local irritation, and now and then even some constitutional derangement. The agents which were at work to produce these conditions were the poisonous dyes called red and yellow coralline. The local action of both these poisons is sharp, and they bring upon the skin a raised eruption of minute round pimples, which I have known to be mistaken for the eruption of measles by the unskilled in diagnosis. The irritation which attends the rash is painful, and if there be much rubbing of the part little vesicles may form and give out a watery discharge. Once I knew an eruption on the chest, caused by a red woolen comforter, attended with much nervous prostration; but, as a rule, the evil is purely local, the coloring matter being not readily absorbed by the skin. This is fortunate, for the poison would be intense if it were to enter the blood.

It is necessary at once to remove the colored garment when it is causing the local mischief, and such garments should never be worn until they have been many times rinsed in boiling water.

VI. Cleanliness in dress, the last passage in my programme, is one on which, to an educated audience, I need not dwell. Health will not be clad in dirty raiment, and those who think it can be will soon find themselves subjected to various minor ailments—oppression, dullness, headache, nausea—which in themselves and singly seem of little moment, but which affect materially the standard of perfect health by which life is blithely and usefully manifested. The want now most felt among the educated, in our large centers, is the means for getting a due supply of well-washed clean clothes. The laundry is still up a tree, and, when you climb to it, it is rarely found worth the labor of the ascent. In London, at this moment, a thousand public laundries are wanted, before that cleanliness which is next to godliness can ever be recognized by the apostles of health who feel that their mission in the world stands second only on the list of goodly and godly labors for mankind.—*Gentleman's Magazine.*

STUDIES IN EXPERIMENTAL GEOLOGY.

By STANISLAS MEUNIER.

M. A. DAUBRÉE, in his recently published "Études Synthétiques de Géologie Expérimentale" (Synthetic Studies in Experimental Geology), besides giving the results of studies on the formation of meteorites and on the production of the chemical and physical phenomena of geology, describes a series of interesting and instructive experiments upon the manner in which the mechanical operations of which the earth's strata bear witness were brought about.

M. Daubrée began this series of experiments with an investigation of the processes by which the convolutions of the stratified beds were produced. With a very simple apparatus, a frame of iron strengthened by long screws crossing two of its contiguous sides, he subjected flexible laminæ, as representing in miniature the strata of the globe, to pressures of varying energy and direction. Under these constantly measured efforts he saw reproduced all the characteristic traits of the geology of regions whose strata are warped, synclinal valleys, anticlinal crests, slopes, and reversals of strata, strata in the form of C, strata in the form of S, etc.

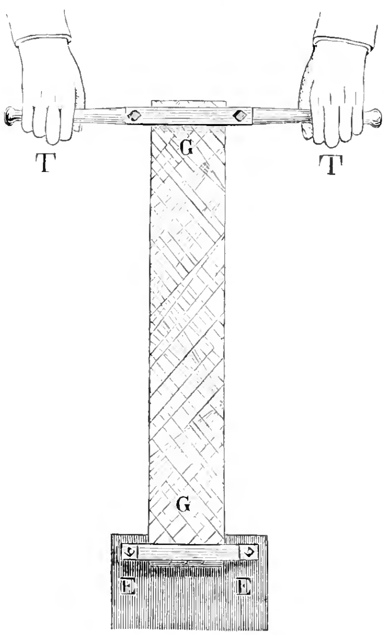


Fig. 1.—Double system of conjugate fractures developed in a plate of glass, G G, by the effect of the torsion produced by the turning-handle, T T. E E, block of wood in which the other end of the glass plate is fastened. (One sixth the natural size.)

Prosecuting his experiments beyond the limits of the elasticity of bent laminæ, M. Daubrée went into the investigation of the origin and mode of formation of terrestrial fractures. He was able by means of his new processes to produce imitations of joints and faults in all their details. An unforeseen result of his experiments was, that they disclosed evidences of mutual coordination between natural fractures which observation alone had failed to notice. This point deserves a careful examination. A rectangular plate of glass, G G (Fig. 1), was clamped between two jaws of wood tightly bound by screws so as to form a kind of vice, E E. The other end of the plate was fitted to a wrench, T T. By turning the wrench around horizontally, M. Daubrée twisted the plate of glass so that it speedily broke into a thousand pieces. Having previously taken care to paste a sheet of paper around the glass so as to make the fragments keep their places and preserve their relative distribution to each other, he found that the fractures, instead of assuming a uniform direction, formed in the glass a network of geometrical regularity. They seemed to be grouped in two directions or systems, equally inclined to the axis of torsion. The two conjugate systems of fractures generally crossed each other at very open angles, the measure of which depended on the relative dimensions of the two sides of the plate. Sometimes the angle was a right angle, sometimes it was reduced to an angle of 70° or less.

These artificial fractures present close analogies with certain geological characteristics of different regions. An example of localities in which a correlation is presented between the subterranean fractures and the reliefs of the surface is presented in the cretaceous beds of the south of France. If we examine attentively a well-made map of this district, we shall see that from the principal valleys, which are parallel to each other, branch out a large number of other valleys, likewise rectilinear and parallel with each other. We can see in them how the thin pellicle which we call the crust of the earth has yielded to strains or torsions analogous to those which the wrench has impressed upon the plate of glass, and how it has become fissured in directions coordinate to each other. In the Spanish part of the massive Mont Perdu, the cretaceous and nummiliferous rocks, in the main horizontal, have been raised to a height of nearly ten thousand feet, and are notched to the depth of four or five thousand feet by narrow valleys, the walls of which are nearly vertical. Another example of this kind of reticulated system is presented in the forms of the coasts, fiords, and principal valleys of a part of Norway.

We already know that the schistous or leafy structure presented by many tracts called metamorphic must be attributed to real laminations. M. Daubrée has make experimental studies on the distortions which the forms of the fossils in the schistous rocks have undergone. The trilobites and mollusks of the neighborhood of Angers very rarely present themselves in any other than deformed shapes which seem like caricatures of the animals from which they are derived. These deformities can be perfectly imitated in experiments. If we inclose the shell of a crawfish in a mass of lead which we then cause to pass through a flattening-mill, we can inflict upon the crustacean a malformation quite like that of the silurian trilobites. A remarkable exemplification of the changes of form which fossils contained in rocks that have become schistous have undergone is presented by the belemnites of different localities in the Alps, in cases where they have been broken into pieces and their segments have been more or less removed from each other. M. Daubrée has produced similar forms of breakage by laminating blocks of lead in the interior of which belemnites had been previously inclosed. Fig. 2 represents a belemnite thus inclosed in a block of lead of which only a half is shown. The effect of laminating is shown in Fig. 3: the fossil has been broken up, and its pieces have been more or less separated from each other, exactly as in the natural examples.

By pursuing a similar line of research, M. Daubrée has succeeded in imitating a characteristic feature of the structure of large chains of

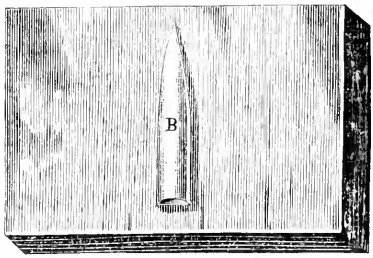


Fig. 2.—*Belemnites niger*, B, closely inclosed by casting in the center of a prism of lead; in two parts, only one of which is represented. The prism is to be subjected to the action of the hydraulic press perpendicularly to its larger sides. (Scale of one half.)

mountains, which Saussure observed on Mont Blanc. The masonry-work of Mont Blanc, says this author, is divided into great leaves having their planes exactly parallel to each other, and parallel to the direction of the chain. He further satisfied himself that the leaves,

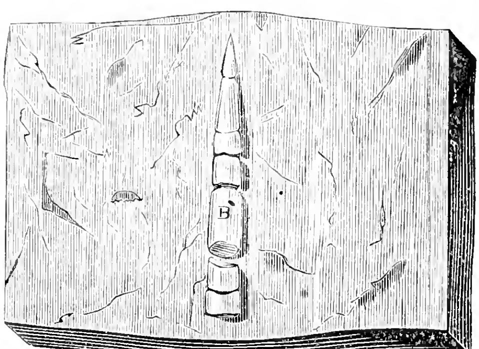


Fig. 3.—Stretching out and truncation of the belemnite of the preceding figure by the action of the hydraulic press on the prism of lead in which it was incased.

nearly vertical in the center of the mass, assumed inclined positions in their lateral parts, and dipped symmetrically toward the central axis, so as to present in their transverse section the form of a half-opened fan. Little Mont Blancs can be reproduced in miniature, with a structure like that described by Saussure, in this way: Take clay which has been previously well mixed and nearly dried, and cut into the form of a square prism; and, having put it between two square plates of the same dimensions as the base of the prism, subject it to the action of the hydraulic press. In the operation a beard (*bavure*) or overflow runs out from each of the four lateral faces, the expanding form of which, in consequence of the change of pressure, adjusts itself with the faces of the prism. The deformed mass exhibits on a transverse fracture an essentially schistous texture, which is thus disposed : in all of the part inclosed between the plates, the leaves are nearly parallel to the two walls, but in the part which passes beyond the plates the leaves bend over and diverge from the axis so as to be parallel to the two exterior surfaces, while they themselves separate more and more. The leafiness is especially marked near the two external surfaces ; it is generally much less so toward the central part. This experiment furnishes a fac-simile (Fig. 4) of the leafy structure called fan-shaped.

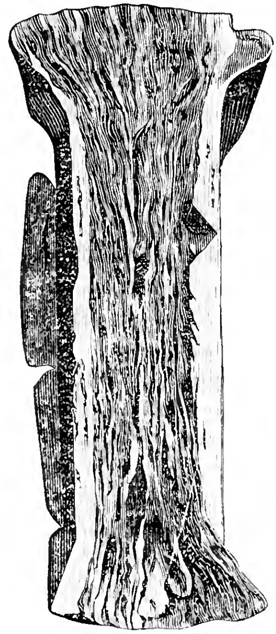


Fig. 4.—Production of the fan-shaped structure in a mass of clay forced to flow out from between two parallel plates. The horizontal pressure of the plates makes it take on first a leafy structure, then the fan-shaped structure as soon as it has passed beyond the limits of the plates. (One third the natural size.)

It remains to call attention to the consideration of the mechanical actions developed in the crust of the globe as the source of the heat-movements to which the metamorphism of rocks is due. M. Daubrée has been led by his experiments to conclude that such is the origin of this phenomenon. The mechanical action which is required to make rocks schistous is enough to heat them to a considerable degree. It is known that a very slight elevation of temperature is sufficient to produce chemical reactions in the depths of rocky masses. The quarry-water, with which all the rocks are impregnated, and that which finds its way to them through fissures, could give rise to reactions which might be prolonged for a protracted period.—*La Nature*.

VIEWS OF PRIMITIVE MARRIAGE.

By LORIMER FISON.

THE theory now to be considered was first advanced by Mr. McLennan, in his work entitled "Primitive Marriage." It will be found stated in the following words in his "Studies in Ancient History,"* a reprint, with additions, of the former work :

"We believe this restriction on marriage (i. e., exogamy) to be connected with the practice in early times of female infanticide, which,

* "Studies in Ancient History," comprising a reprint of "Primitive Marriage." By John Ferguson McLennan, M. A., LL. D. Quaritch, London, 1876.

rendering women scarce, led at once to polyandry within the tribe, and to the capturing of women from without." *

"If it can be shown, firstly, that exogamous tribes exist or have existed, and, secondly, that in rude times the relations of separate tribes are uniformly or almost uniformly hostile, we have found a set of circumstances in which men could get wives only by capturing them—a social condition in which capture would be the necessary preliminary to marriage." †

Further on he remarks, "We now confidently submit that the conditions required for this inference have been amply established. . . ." ‡

After a careful study of Mr. McLennan's work, I am not sure that I have grasped his meaning here. The "tribe" of which he speaks must have been in the first place endogamous, because he supposes it to have become exogamous as the result of the practice of female infanticide. Here, then, we have an endogamous tribe becoming exogamous. But, in the table of contents to Chapter VII. we read, "Conversion of an endogamous tribe into an exogamous tribe inconceivable." Turning to that part of the body of the work here indicated, we find the statement to be that the "*re*conversion of an endogamous tribe into an exogamous tribe is inconceivable." But this does not help us. For there can be no difficulty in conceiving that which we have before our eyes at the present day in almost all savage peoples on the face of the earth—a tribe endogamous *qua* tribe—that is, marrying within its own limits, and yet split up into exogamous intermarrying divisions, classes, gentes, septs, clans, thums, keelis, or whatsoever else they may be called ; so that the law of marriage is distinctly exogamous. The confusion here evidently arises from want of precision in the use of the terms endogamy, exogamy, and tribe. Let us know the exact boundaries of the group to which they are applied, and then we shall be clear as to their meaning.

Again, turning to the general theory as set forth in Mr. McLennan's words already quoted, we find the following sequence :

1. Female infanticide was the general practice among the "primary hordes," and resulted in a scarcity of women, so causing polyandry and marriage by capture.

2. The tribe having thus taken to capturing women, acquired the habit of so doing, and became exogamous.

3. Exogamy having thus grown into a law, and neighboring tribes being, as a rule, hostile to one another, men could get their wives no otherwise than by capture.

Which may be fairly summed up as follows : Female infanticide causes marriage by capture. Marriage by capture causes exogamy. Exogamy causes marriage by capture.

I can not suppose this to have been Mr. McLennan's meaning, but

* "Studies," etc., p. 111. † Ibid., p. 42. ‡ Ibid., p. 109.

I have failed to perceive any other. Two things, however, are clear, as forming the basis on which his theory stands:

1. That "female infanticide" was the general practice among the "primary hordes"—in other words, that they killed many more female children than male.

2. That exogamous tribes existed under "circumstances in which men could only get wives by capturing them"—in other words, that these tribes could not marry *anywhere within their own boundaries*, and were consequently compelled to capture their wives, there being no possibility of friendly intermarriage with other tribes.

Let us now test this basis, and see if it be secure: It is well known that infanticide is a very common practice among savage and barbaric tribes, and the opinion seems to prevail that "female infanticide"—the killing of female children rather than male—is the general rule. This opinion is undoubtedly correct as to many tribes; but I venture to suggest that it needs reconsideration *as far as the lower savages are concerned*, and it is with them that the theory now under consideration has to do. I think it will be found that the practice is far less common with them than it is among the tribes who are more advanced, and for this opinion I will now endeavor to show cause.

Savages are perfectly logical people in their own way, and do not act without a motive, which, to their minds at least, is a sufficient one. So thoroughly have I been convinced of this by my fifteen years' residence among them, and close observation of their ways, that I do not hesitate to affirm that, whenever their acts appear capricious to us, we may be quite sure we do not understand their motives. The savage has no hesitation in killing his infant children, whether male or female, if they be in his way; but he does not kill any one of them for the mere sake of killing, and he certainly would not kill his daughters rather than his sons without a sufficient motive. Is such a motive to be found among the lower savages?

The reasons usually given for female infanticide are thus stated by Sir John Lubbock and Mr. McLennan:

"Female children became a source of weakness in various ways. They ate and did not hunt. They weakened their mothers when young, and when grown up were a temptation to surrounding tribes." *

To the same effect Mr. McLennan observes: "To tribes surrounded by enemies and unaided by art, contending with the difficulties of subsistence, sons were a source of strength, both for defense and in quest of food, daughters a source of weakness." †

The motive here advanced is, that *females are an incumbrance to savages*, and for this four reasons are given:

1. "They weaken their mothers when young."

* "Origin of Civilization," second edition, p. 108.

† "Studies," etc., p. 111.

2. "They eat and do not hunt"—i. e., they are food-consumers, but not food-providers.

3. They are "a source of weakness" as regards defense—i. e., they are in the way in war-time.

4. They are "a temptation to surrounding tribes."

I think it can be shown that not one of these reasons is of any force as regards the lower savages.

1. That children "weaken their mothers when young" may be a reason for infanticide, but it is no reason for killing female infants rather than male.

2. The assertion that women "eat and do not hunt" can not apply to the lower savages. On the contrary, whether among the ruder agricultural tribes, or those who are dependent on supplies gathered "from forest and from flood," the women are food-providers who supply more than they consume, and render most valuable service into the bargain. As a general rule they are the hardest workers and the most useful members of the community in times of peace.

3. And certainly they are not "a source of weakness" as regards defense. They are perfectly capable of taking care of themselves * in war-time; and, so far from being an incumbrance upon the warriors, they will fight, if need be, as bravely as the men, and with even greater ferocity. I could give some shocking proofs of this which have come under my own observation.

4. Finally, that they are "a temptation to surrounding tribes" does not appear to be a sufficient reason for killing them. They are far too valuable a possession to be cast away merely because the neighbors covet them. We do not find the Caffres exterminating their cattle because they are "a temptation to the surrounding tribes."

It is among the more advanced tribes that the motives for female infanticide are found, and I believe the practice exists also to a greater extent than among the lower savages. Thus, where a costly dower has to be given with a girl in marriage, female infanticide is known to be very common. A daughter there is a special cause of impoverishment to her parents, whereas a son is a cause of enrichment. Here we have a motive which seems to act with considerable power, but it does not exist among the lower savages. For with them the dower—where one is given—is provided by the bridegroom's kinsmen and presented to the parents of the girl. Here, then, the conditions are reversed. It is the girl who is a cause of enrichment to her

* They who are accustomed to the ways of civilized women only can hardly believe what savage women are capable of even when they may well be supposed to be at their weakest. For instance, an Australian tribe on the march scarcely takes the trouble to halt for so slight a performance as a childbirth. The newly-born infant is wrapped in opossum-skins, the march is resumed, and the mother trudges on with the rest. Indeed, as is well known, among many tribes, it is the father who is put to bed, while the mother goes about her work as if nothing had happened.

parents at her marriage. And this is very far from being all the advantage they derive from her. Her husband has to feed them in peace, and to fight for them in war. Thus an Australian native divides all the game he takes according to certain established rules, and the choicest bits go to his wife's father. That a man has to fight on his father-in-law's side among many tribes who reckon descent through females has been recorded by several observers of savage life ; and it is worthy of note that this duty still devolves upon him in some tribes, which, though they have advanced to descent through males, have not yet been able to free themselves from the traditions of the older line. Thus the Rev. R. Taylor says of the Maori—who keep records, carefully carved in wood, of long lines of male ancestors reaching up to the *Nichts und Alles*—that the son-in-law had to go into his father-in-law's *hapu* (clan) and "in case of war was often obliged to fight against his own relatives.* The custom was evidently on the way to extinction among the Maori, though still retaining great strength. This is evident from the fact that there was much rebellion against it on the part of the young men, some of whom, within Mr. Taylor's knowledge, refused to obey, and lost their wives in consequence ; and, whenever there is as much opposition as this to an ancient custom among savages, we may be sure that a new custom has gained a footing strong enough to afford a sanction to the malcontents. That this custom is likely to be of general prevalence among the lower savages is evident from the fact that it is the logical result of their group-relationships when descent is through the mother. Among them it is not that a man has to leave his own clan and go into his father-in-law's when he marries. He is of his father-in-law's clan by birth. Thus, if Dog and Snake be the totems, or badges, of two intermarrying clans : with descent through females the daughter of Dog is Snake, and the son of Snake is Dog. This Dog, the son of Snake, marries Snake, the daughter of Dog. That is, father-in-law and son-in-law are of the same totem, where there are but two intermarrying gentes ; and a strong probability can be shown that this is the earliest form of a tribe with exogamous intermarrying divisions.

Therefore, since women are in no respect an incumbrance to the lower savages, but the reverse, it is evident that we do not find in the reasons given by Sir John Lubbock and Mr. McLennan a preferential motive for female infanticide.

And something more than this can be shown. Another motive for killing female children rather than male is found among agricultural tribes, who have descent through the father, in the fact that a woman can transmit neither the family name nor the family estate. She passes out of the line by marriage. And this with tribes who have that line of descent, and therefore—wherever they accept its consequences—ancestral worship offered to males alone by males alone, this

* "Te Ika a Maui," p. 337.

is a very grave—the very gravest—consideration. The dead are dependent upon their male descendants for offerings, without which their shadowy existence would be to the last degree wretched; and therefore, as every man knows he also must die, he is anxious during life to see a good provision made for his future wants—in other words, he is eager to have sons to succeed him. But neither is this motive to be found among the lower savages, for with them descent, and therefore inheritance, is through females. Hence we find in some such tribes the practice of "male infanticide"—that is to say, *the practice of killing male children rather than female.* Thus the Rev. R. H. Codrington, M. A., of the Church of England Melanesian mission, informed me, with regard to the people of Mota (Banks Island), that infanticide was common among them, and that "*male children were killed rather than female, because of the family passing by the female side.*"

We have seen that the first of the two postulates on which Mr. McLennan's theory depends is not to be readily granted. We have now to examine the second, which is—

That exogamous tribes existed "under circumstances in which men could get wives only by capturing them."

A tribe to satisfy these conditions must be exogamous *qua* tribe—that is to say, marriage must be forbidden everywhere within its limits. No man of the tribe must be able to take any one of its women to wife; for, if the tribe be so constituted that its men can get their wives anywhere within its boundaries, it is manifest that it is not a tribe such as Mr. McLennan's theory requires.

His list of what he calls "exogamous tribes" is contained in Chapter V. of "Studies in Ancient History," and of all those tribes there is not one which satisfies his own conditions. Without exception, they are all divided into exogamous intermarrying clans; and therefore they can get wives without capturing them from other tribes.

Each one of them is *an endogamous tribe or community, made up of exogamous intermarrying clans*—that is, it marries within its own boundaries, but it prohibits marriage within any one of its clans. Once more we have to note that a confusion arises from Mr. McLennan's want of precision in using the term "tribe," and his own terms "endogamy" and "exogamy," all of which are equally misleading, unless the area to which they are applied be clearly defined. But, whatever be the meaning which he gives to *tribe*, the cases cited by him in his fifth chapter are of no avail. For it is evident that in these cases the word "tribe" must mean one of two things: either—

1. The whole nation or community; or—

2. One of the exogamous clans—or the exogamous clans severally—into which the nation is divided.

In either case the examples cited by Mr. McLennan are valueless; because—

1. If by "tribe" he means the nation or community, then the tribes cited are not exogamous. They marry within their own bounds.

2. If by "tribe" he means the exogamous clans, then the tribes cited are not found under "circumstances in which men could get wives only by capturing them." The clans have peaceful intermarriage with one another.*

As this statement can be verified by a reference to Mr. McLennan's own account of the tribes which he cites as "exogamous," there is no need to trouble the reader with an examination of more than two or three of them which seem to require special notice. Of these the first are the Calmucks, who are divided into four great tribes or nations, called respectively Khoshot, Dzungar, Torgot, and Derbet (or Tchoro). Their system of marriage seems to have this peculiarity, that the common people can marry within any one of these great divisions, though not within certain prohibited degrees, while the nobles must marry each without his own division. A Derbet noble, for instance, we are told, must marry a Torgot lady, a Torgot noble a Derbet lady, and so on. Each of these great divisions is subdivided into smaller divisions, but we are not told whether these subdivisions are exogamous or not.

I know very little about the Calmucks, and a mission station in Feejee affording no facilities for getting at books of reference, I am not in a position to ascertain more fully the Calmuck system of marriage. We know, however, that the Calmucks call themselves the "Derben Ueirat," which means "The Four Relatives"; and this fact, coupled with the law of marriage among the nobles—who are conservatives almost everywhere, and given to standing in the old paths—seems to point to a time when the four great divisions were simply intermarrying clans, making up one community. But, whether this were so or not, it is evident that the Calmucks will not serve Mr. McLennan's turn, unless we may take it for granted that there was a time in their history when they had no way of marrying save by capturing each other's women.

Let us grant this for the sake of argument, and see what comes of it. Derbet and Torgot, we will say, are two exogamous tribes living in a state of mutual hostility, and so presenting "a set of circumstances in which men can get wives only by capturing them." Now, what is the result? Say that Derbet captures a number of Torgot women sufficient to supply its young men with wives, and Torgot captures Derbet women enough for its wants; we may then ask, "Are all the women on both sides disposed of?" If so, it follows that each tribe has captured all the women of the other.

But, if there be any women left uncaptured, what are they to do

* This has been pointed out by Mr. Morgan also. (See "Ancient Society," p. 513.)

for husbands? Say, for instance, that a number of Derbet girls are left uncaptured by the Torgots, who have secured their full complement of wives. What is to be done with them? They can not marry within their own tribe, for the tribe is exogamous. The Derbets must be in this perplexing strait: either they must give these women away to the Torgots—which would be a method of wife-procuring other than capture—or they must capture Torgot young men as husbands for those damsels, and forcibly adopt them into their own tribe.

Mr. McLennan's theory of marriage by capture, therefore, requires either—

1. That all the women of a tribe shall be captured by another tribe; or—

2. That men shall be captured for husbands, as well as women for wives. Surely, when a theory brings us to a conclusion such as this, it were better to lay it aside.

The Kocchs and the Hos, brought forward in evidence by Mr. McLennan in a subsequent chapter, are useless witnesses to him, because, as Sir John Lubbock has pointed out, "they are divided into *keelis*, or clans, and may not take to wife a girl of their own keeli."*

Concerning the Khonds, Major McPherson's statement, quoted by Mr. McLennan, is that "intermarriage between persons *of the same tribe*" (the italics are mine), "however large or scattered, is considered incestuous and punishable by death." This does not prove that no Khond can marry a Khond—and nothing less than this is required by Mr. McLennan's theory. It simply points to the fact that the Orissa Khonds are divided into exogamous clans, and that men and women of the same clan are tribal brothers and sisters.

Taking the term "exogamous tribe" to mean an exogamous community complete in all its parts, and forbidding marriage everywhere within its limits (the sense in which Mr. McLennan's theory requires it to be used with regard to the cases cited by him in his fifth chapter), I do not hesitate to say that nowhere on the face of the earth has such a tribe been found at the present day; and that we have no trustworthy record of any such tribe having existed in bygone days. All the savage communities with which we have anything like a full acquaintance are made up of exogamous intermarrying divisions, and consequently do not forbid marriage everywhere within their own limits. Such a community may properly be said to be *endogamous* as regards itself, if it forbids or at least discourages marriage beyond its own boundaries (as is frequently—we may say generally—the case), though its law of marriage can not be said to be endogamous, because its clans are strictly exogamous. There is no instance, as far as I know, of any such endogamous tribe which is not divided into exogamous clans. If we could find such a tribe, we should find what has been diligently sought for in vain for the last thirty years and more.

* "Origin of Civilization," second edition, p. 117.

It would be an undivided commune, to the former existence of which significant evidence has long seemed to point.

The case of the Ahts, quoted from Sproat's "Scenes and Studies of Savage Life," by Sir John Lubbock,* and apparently brought forward by him as an instance of such a tribe, is far from being a case in point. Sproat's account of the Ahts does not prove that tribe to be endogamous, excepting in the sense that a tribe made up of exogamous clans may be said to be endogamous because it prefers not to go beyond its own clans for its wives. If this be endogamy, then the term endogamy is of little value; for in this sense nearly every nation on the face of the earth may be said to be endogamous, in feeling at least. Even among the English the "foreigner" is not looked upon as an altogether eligible husband excepting for princesses, and for them only because of ancient traditions. It is the Calmuck rule over again. The common people may marry at home, but a Derbet noble must marry one of the Torgot stock. One of the good deeds the Queen has done is her breaking through this rule in the case of one of her daughters. And, even if one of her sons had taken an English or an American lady to wife, there is little doubt that the nation would have applauded his choice, in spite of all the old traditions. But this is going a long way from our subject.

What Sproat tells us of the Ahts is that "the idea of slavery connected with capture is so common that a freeborn Aht would hesitate to marry a woman taken in war, whatever her rank had been in her own tribe." And this feeling is a very common one elsewhere. With reference to this passage in the "Origin of Civilization," Mr. Walter Carew, Commissioner for the Interior of Naviti Levu, Feejee, was good enough to write me the following note: "To call a person 'a child of a captive' is a very great insult, even though the mother were of high rank." Mr. Carew goes on to remind me of a case, with the circumstances of which we are both acquainted, of a Viria chief who was set aside because his mother was a captive, though she was a *marama*, or lady of rank, belonging to one of the principal tribes in Feejee, a tribe of far greater consequence than that of Viria.

Having examined Mr. McLennan's theory of exogamy and marriage by capture, it now remains for us to notice his statement of polyandry.

If what we have to deal with here were no more than a statement that local cases of polyandry are to be found, or even that such cases are of frequent occurrence, the controversy would be of no very great importance. But Mr. McLennan treats polyandry as a *system of marriage* of so extensive a prevalence, and draws with singular ability such wide inferences from it as to kinship, succession, and the change of descent from the female line to the male, that all the most impor-

* "Origin of Civilization," p. 117.

tant questions connected with the development of social organization in early communities are involved. The evidence, therefore, ought to be of the very strongest, and the witnesses fully competent to deal with the facts they narrate.

In forming our opinions as to the customs of savage tribes, in all cases where the significance of a custom depends upon something underlying the visible facts, the accounts given by travelers must be received with caution. They may state quite correctly each fact they observe, but they are very likely to be wrong in their interpretation of its meaning. No witness here is to be trusted unless he has had very full opportunities of making himself acquainted with that which underlies the custom he describes. This caution has a special application to evidence as to polyandry; for, as Sir John Lubbock justly observes, "When our information is incomplete, it must often be far from easy to distinguish between communal marriage and true polyandry." * Thus Mr. Schurmann, who happened to observe two Australian blacks living with one woman in common between them, records this as an instance of polyandry, whereas we know that it was nothing more than an instance of group-marriage. So also the practice of the "imported laborers" † in Feejee at the present day might well be set down as polyandry, if we did not know what is beneath the outer fact. There is an exceptional scarcity of women among them, many more males than females being imported; and so a woman may be seen cohabiting with a number of men. But we have had more than one shocking proof that this seeming polyandry is only group-marriage in difficulties, women who admitted men of a forbidden class having been put to death by their countrymen for the offense; and the murderers have declared that they were under obligation to kill them.

Not a few of Mr. McLennan's instances of so-called polyandry admit of a similar explanation; and even those cases on which he seems chiefly to depend—the Nair and the Thibetan—are anything but conclusive in his favor. The Nair polyandry, according to the account of it given by Mr. McLennan himself in quotation from Hamilton, Buchanan, and the "Asiatic Researches," ‡ is evidently group-marriage. A Nair woman has "a combination of husbands," but "a Nair may be one in several combinations of husbands—that is, he may have any number of wives." Group-marriage might well be described in these very words. That the Nairs are divided into exogamous clans is certain from the fact that cohabitation is regulated by "certain restrictions as to tribe and caste," the plain meaning of which is that there are certain "tribes or castes" which do not intermarry; and the

* "Origin of Civilization," p. 116.

† These are natives of other South-Sea Island groups, brought to Feejee as laborers on the plantations, etc.

‡ "Studies," etc., p. 149.

Nair polyandry resolves itself into cohabitation between permitted groups. Mr. McLennan asserts that "the Nair husbands are usually not brothers—usually not relatives." But in what sense does he use "brothers" and "relatives" here? If by "brothers" he means only "children of the same parents," and by "relatives" only "persons who are related according to our own notions of relationship," then his statement is of little weight, for a group of "tribal" brothers may include many persons other than these.

The Thibetan instance quoted from Turner, where "five brothers were living very happily under the same connubial compact" * seems to be a clearer case. But there is no proof that this is an instance of true polyandry, and not of polyandry combined with polygynia, like the Nair custom, the custom of the Britons as described by Cæsar † and all the other instances given by Mr. McLennan where tribal brothers hold their wives in common. And, considering how easy it is to mistake instances of group-marriage for polyandry, such proof may be reasonably demanded from one who represents polyandry as an extensive system of marriage.

The law of the Levirate, which Mr. McLennan considers "it is impossible not to regard as . . . derived from the practice of polyandry," ‡ does not appear to me to have anything at all to do with polyandry. It was a regulation to prevent the elder branch of a stock from becoming extinct. Its underlying motive is found in the preferential claim to the birthright vested in the elder branch; and this preferential claim is found only in tribes who have descent through males, or at least who, having settled down to agriculture, are well on their way to that line. The lower savages know nothing of that motive. Mr. McLennan lays stress upon the fact that the widow was the Levir's "wife without any form of marriage." But there is no proof that this is a survival of polyandry; for, in the first place there is no need for us to look upon it as a survival of anything at all, and, in the second place, it would serve very well as a survival of group-marriage. In many tribes the brother's widow is the Levir's wife "without any form of marriage." He does not even wait until she becomes a widow. He is of the same group with her husband, and her group is "wife" to his group.

It is not denied that cases of polyandry occur. A few instances of it have come under my own observation. But in every case the men were of a clan which intermarried with that of the woman, the circumstances were exceptional, and the custom was not the general practice—not even the frequent practice—of the tribe. In full accordance with this is the following account of polyandry at Mota, written to me by the Rev. R. H. Codrington before mentioned:

"Polyandry exists, but rarely—never with young people, but mostly as a matter of convenience, as when two widowers live with

* "Studies," etc., p. 155. † "De Bello Gallico," v., 14. ‡ "Studies," etc., p. 163.

one widow. She is wife to both, and any child she may have belongs to both. There are cases in which a husband connives at a connection between his wife and another man. This is not counted adultery, for it is an open transaction; and it is not polyandry, for the parties are not counted husband and wife. It is not considered respectable."

The existence of polyandry is not denied, but I venture to hazard the assertion that it is not *the system of marriage* in any tribe at the present day, and it seems to me impossible that it could have been the rule of marriage anywhere at any time in the past. The mere arithmetical difficulty in the way appears to me to be insurmountable.

Though such statistics as I have been able to get at among the lately heathen tribes in Feejee directly contradict the hypothesis, still I think we may suppose that the number of males generally exceeds that of females among the lower savages. But it does not seem to have occurred to Mr. McLennan to consider how great his theory of polyandry as a system of marriage requires that disparity to be. Under such a system it is evident that, whatever the average number of husbands to a wife may be, at least so many times more numerous must the men be than the women. If y be the number of women, and x their average allowance of husbands; then, since we can not suppose that under such a system any marriageable girl would be allowed to roam in "maiden meditation fancy free," the number of men in the tribe must be $x\ y$, even supposing all the men to be absorbed in the "combinations of husbands."

Nor will marriage by capture help us here; because, for every woman stolen there must have been x husbands left lamenting, unless we suppose that a non-polyandrous tribe was kept in the neighborhood of each polyandrous tribe for its convenience, and that they never retaliated upon their aggressive neighbors.

To sum up: It has been shown that Mr. McLennan's postulate of female infanticide as the rule among the lower savages can not easily be granted; that his exogamous tribes are not exogamous in the sense which his theory requires; and that both marriage by capture and polyandry, as systems of marriage, involve something which has all the appearance of an absurdity. Without claiming too much, then, I think it may be said that the basis of Mr. McLennan's theory has been shown to be insecure. And this being so, it is all the greater pity that he allowed himself to treat with such contemptuous scorn the hypothesis advanced by Mr. Morgan in his work on "Systems of Consanguinity,"* which hypothesis is opposed to his own.

"This wild dream—not to say nightmare—of early institutions . . . . It seemed worth while to take the trouble to show its utterly un-

* "Systems of Consanguinity and Affinity of the Human Family," "Smithsonian Contributions to Knowledge," vol. xvii.

scientific character." * Before a writer permits himself to use words such as these, he should be very sure that he has firm ground under his feet; and even then it would be better to leave them unsaid. There is nothing in any line of scientific research to make a man of undoubted learning and ability forget the courtesy which he owes to another.

GOETHE'S FARBENLEHRE.—(THEORY OF COLORS.†)

By Professor JOHN TYNDALL, F. R. S.

I.

IN the days of my youth, when life was strong and aspiration high, I found myself standing one fine summer evening beside a statue of Goethe in a German city. Following the current of thought and feeling started by the associations of the place, I eventually came to the conclusion that, judging even from a purely utilitarian point of view, a truly noble work of art was the most suitable memorial for a great man. Such a work appeared to me capable of exciting a motive force within the mind which no purely material influence could generate. There was then labor before me of the most arduous kind. There were formidable practical difficulties to be overcome, and very small means wherewith to overcome them, and yet I felt that no material means could, as regards the task I had undertaken, plant within me a resolve comparable with that which the contemplation of this statue of Goethe was able to arouse.

My reverence for the poet had been awakened by the writings of Mr. Carlyle, and it was afterward confirmed and consolidated by the writings of Goethe himself. But there was one of the poet's works, which, though it lay directly in the line of my own studies, remained for a long time only imperfectly known to me. My opinion of that work was not formed on hearsay. I dipped into it so far as to make myself acquainted with its style, its logic, and its general aim; but having done this I laid it aside, as something which jarred upon my conception of Goethe's grandeur. The mind willingly rounds off the image which it venerates, and only acknowledges with reluctance that it is on any side incomplete; and believing that Goethe in the "Farbenlehre" was wrong in his intellectual, and perverse in his moral judgments—seeing, above all things, that he had forsaken the lofty impersonal calm which was his chief characteristic, and which had entered into my conception of the godlike in literature—I abandoned

* "Studies," etc., pp. 360, 371.

† A discourse delivered in the Royal Institution of Great Britain, on Friday evening, March 19, 1880.

the "Farbenlehre," and looked up to Goethe on that side where his greatness was uncontested and supreme.

But in the month of May, 1878, Mr. Carlyle did me the honor of calling upon me twice; and I, not being at home at the time, visited him in Chelsea soon afterward. He was then in his eighty-third year, and, looking in his solemn fashion toward that portal to which we are all so rapidly hastening, he remembered his friends. He then presented to me, as "a farewell gift," the two octavo volumes of letter-press and the single folio volume, consisting in great part of colored diagrams, which are here before you. Exactly half a century ago these volumes were sent by Goethe to Mr. Carlyle. They embrace the "Farbenlehre"—a title which may be translated, though not well translated, "Theory of Colors"—and they are accompanied by a long letter, or rather catalogue from Goethe himself, dated the 14th of June, 1830, a little less than two years before his death. My illustrious friend wished me to examine the book, with a view of setting forth what it really contained. This year for the first time I have been able to comply with the desire of Mr. Carlyle; and as I knew that your wish would coincide with his, as to the propriety of making some attempt to weigh the merits of a work which exerted so great an influence in its day,* I have not shrunk from the labor of such a review.

The average reading of the late Mr. Buckle is said to have amounted to three volumes a day. But they could not have been volumes like those of the "Farbenlehre." For the necessity of halting and pondering over its statements was so frequent and the difficulty of coming to any undoubted conclusion regarding Goethe's real conceptions was often so great as to invoke the expenditure of an inordinate amount of time. I can not even now say with confidence that I fully realize all the thoughts of Goethe. Many of them are strange to the scientific man. They demand for their interpretation a sympathy beyond that required or even tolerated in severe physical research. Two factors, the one external and the other internal, go to the production of every intellectual result. There is the evidence without and there is the mind within on which that evidence impinges. Change either factor, and the result will cease to be the same. In the region of politics, where mere opinion comes so much into play, it is only natural that the same external evidence should produce different convictions in different minds. But in the region of science, where demonstration instead of opinion is paramount, such differences ought hardly to be expected. That they nevertheless occur is strikingly exemplified by the case before us; for the very experimental facts

* The late Sir Charles Eastlake translated a portion of the "Farbenlehre"; while the late Mr. Lewes, in his "Life of Goethe," has given a brief but very clever account of the work. It is also dealt with, in connection with Goethe's other scientific labors, in Helmholtz's lectures.

which had previously converted the world to Newton's views, on appealing to the mind of Goethe, produced a theory of light and colors in violent antagonism to that of Newton.

Goethe prized the "Farbenlehre" as the most important of his works. "In what I have done as a poet," he says to Eckermann, "I take no pride, but I am proud of the fact that I am the only person in this century who is acquainted with the difficult science of colors." If the importance of a work were to be measured by the amount of conscious labor expended in its production, Goethe's estimate of the "Farbenlehre" would probably be correct. The observations and experiments there recorded astonish us by their variety and number. The amount of reading which he accomplished was obviously vast. He pursued the history of optics, not only along its main streams, but on to its remotest rills. He was animated by the zeal of an apostle, for he believed that a giant imposture was to be overthrown, and that he was the man to accomplish the holy work of destruction. He was also a lover of art, and held that the enunciation of the true principles of color would, in relation to painting, be of lasting importance. Thus positively and negatively he was stimulated to bring all the strength he could command to bear upon this question.

The greater part of the first volume is taken up with Goethe's own experiments, which are described in nine hundred and twenty paragraphs duly numbered. It is not a consecutive argument, but rather a series of jets of fact and logic emitted at various intervals. I picture the poet in that troublous war-time, walking up and down his Weimar garden, with his hands behind his back, pondering his subject, throwing his experiments and reflections into these terse paragraphs, and turning occasionally into his garden-house to write them down. This first portion of the work embraces three parts, which deal respectively with—Physiological or Subjective Colors, with Physical or Prismatic Colors, and with Chemical Colors and Pigments. To these are added a fourth part, bearing the German title "Allgemeine Ansichten nach innen"; a fifth part, entitled "Nachbarliche Verhältnisse," neighboring relations; and a sixth part, entitled "Sinnlich-sittliche Wirkung der Farbe," sensuously-moral effect of colors. It is hardly necessary to remark that some of these titles, though doubtless pregnant with meaning to the poet himself, are not likely to commend themselves to the more exacting man of science.

The main divisions of Goethe's book are subdivided into short sections, bearing titles more or less shadowy from a scientific point of view: Origin of White; Origin of Black; Excitement of Color; Heightening; Culmination; Balancing; Reversion; Fixation; Mixture real; Mixture apparent; Communication actual; Communication apparent. He describes the colors of minerals, plants, worms, insects, fishes, birds, mammals, and men. Hair on the surface of the human body he considers indicative rather of weakness than of strength.

The disquisition is continued under the headings: How easily Color arises; How energetic Color may be; Heightening to red; Completeness of Manifold Phenomena; Agreement of Complete Phenomena; How easily Color disappears; How durable Color remains; Relation to Philosophy; Relation to Mathematics; Relation to Physiology and Pathology; Relation to Natural History; Relation to General Physics; Relation to Tones. Then follows a series of sections dealing with the primary colors and their mixtures. These sections relate less to science than to art. The writer treats, among other things, of—Æsthetic Effects; Fear of the Theoretical; Grounds and Pigments; Allegorical, Symbolical, and Mystical Use of Colors. The headings alone indicate the enormous industry of the poet; showing at the same time an absence of that scientific definition which he stigmatized as "pedantry" in the case of Newton.

In connection with this subject, Goethe charged himself with all kinds of kindred knowledge. He refers to ocular spectra, quoting Boyle, Buffon, and Darwin; to the paralysis of the eye by light; to its extreme sensitiveness when it awakes in the morning; to irradiation—quoting Tycho Brahe on the comparative apparent size of the dark and the illuminated moon. He dwells upon the persistence of impressions upon the retina, and quotes various instances of abnormal duration. He possessed a full and exact knowledge of the phenomena of subjective colors, and described various modes of producing them. He copiously illustrates the production by red of subjective green, and by green of subjective red. Blue produces subjective yellow, and yellow subjective blue. He experimented upon shadows, colored in contrast to surrounding light. The contrasting subjective colors he calls "geforderte Farben," colors "demanded" by the eye. Goethe gives the following striking illustration of these subjective effects: "I once," he said, "entered an inn toward evening, when a well-built maiden, with dazzlingly white face, black hair, and scarlet bodice and skirt came toward me. I looked at her sharply in the twilight, and when she moved away, saw upon the white wall opposite a black face with a bright halo round it, while the clothing of the perfectly distinct figure appeared of a beautiful sea-green." With the instinct of the poet, Goethe discerned in these antitheses an image of the general method of nature. Every action, he says, implies an opposite. Inhalation precedes expiration, and each systole has its corresponding diastole. Such is the eternal formula of life. Under the figure of systole and diastole the rhythm of nature is represented in other portions of the work.

Goethe handled the prism with great skill, and his experiments with it are numberless. He places white rectangles on a black ground, black rectangles on a white ground, and shifts their apparent positions by prismatic refraction. He makes similar experiments with colored rectangles and disks. The shifted image is sometimes projected on a screen, the experiment being then "objective." It is sometimes looked at directly through the prism, the experiment being then "subjective." In the production of chromatic effects, he dwells upon the absolute necessity of *boundaries*—"Gränzen." The sky may be looked at and shifted by a prism without the production of color; and if the white rectangle on a black ground be only made wide enough, the center remains white after refraction, the colors being confined to the edges. Goethe's earliest experiment, which led him so hastily to the conclusion that Newton's theory of colors was wrong, consisted in looking through a prism at the white wall of his own room. He expected to see the whole wall covered with colors, this being, he thought, implied in the theory of Newton. But to his astonishment it remained white, and only when he came to the boundary of a dark or a bright space did the colors reveal themselves. This question of "boundaries" is one of supreme importance to the author of the "Farbenlehre"; the end and aim of his theory being to account for the colored fringes produced at the edges of his refracted images.

Darkness, according to Goethe, had as much to do as light with the production of color. Color was really due to the commingling of both. Not only did his white rectangles upon a black ground yield the colored fringes, but his black rectangles on a white ground did the same. The order of the colors seemed, however, different in the two cases. Let a visiting-card, held in the hand between the eye and a window facing the bright firmament, be looked at through a prism, then supposing the image of the card to be shifted upward by refraction, a red fringe is seen above and a blue one below. Let the back be turned to the window and the card so held that the light shall fall upon it; on being looked at through the prism, blue is seen above and red below. In the first case the fringes are due to the decomposition of the light adjacent to the edge of the card, which simply acts as an opaque body, and might have been actually black. In the second case the light decomposed is that coming from the white surface of the card itself. The first experiment corresponds to that of Goethe with a black rectangle on a white ground; while the second experiment corresponds to Goethe's white rectangle on a black ground Both these effects are immediately deducible from Newton's theory of colors. But this, though explained to him by physicists of great experience and reputation, Goethe could never be brought to see, and he continued to affirm to the end of his life that the results were utterly irreconcilable with the theory of Newton.

In his own explanations Goethe began at the wrong end, inverting the true order of thought, and trying to make the outcome of theory its foundation. Apart from theory, however, his observations are of great interest and variety. He looked to the zenith at midnight, and found before him the blackness of space, while in daylight he saw the blue firmament overhead; and he rightly adopted the conclusion that this coloring of the sky was due to the shining of the sun upon a turbid medium with darkness behind. He by no means understood the physical action of turbid media, but he made a great variety of experiments bearing upon this point. Water, for example, rendered turbid by varnish, soap, or milk, and having a black ground behind it, always appeared blue when shone upon by white light. When, instead of a black background, a bright one was placed behind, so that the light shone, not *on*, but *through* the turbid liquid, the blue color disappeared, and he had yellow in its place. Such experiments are capable of endless variation. To this class of effects belongs the painter's "chill." A cold, bluish bloom, like that of a plum, is sometimes observed to cover the browns of a varnished picture. This is due to a want of optical continuity in the varnish. Instead of being a coherent layer it is broken up into particles of microscopic smallness, which virtually constitute a turbid medium and send blue light to the eye.

Goethe himself describes a most amusing illustration, or, to use his own language, "a wonderful phenomenon," due to the temporary action of a turbid medium on a picture: "A portrait of an esteemed theologian was painted several years ago by an artist specially skilled in the treatment of colors. The man stood forth in his dignity clad in a beautiful black velvet coat, which attracted the eyes and awakened the admiration of the beholder almost more than the face itself. Through the action of humidity and dust, however, the picture had lost much of its original splendor. It was therefore handed over to a painter to be cleaned and newly varnished. The painter began by carefully passing a wet sponge over the picture. But he had scarcely thus removed the coarser dirt, when to his astonishment the black velvet suddenly changed into a light-blue plush; the reverend gentleman acquiring thereby a very worldly, if, at the same time, an old-fashioned appearance. The painter would not trust himself to wash further. He could by no means see how a bright blue could underlie a dark black, still less that he could have so rapidly washed away a coating capable of converting a blue like that before him into the black of the original painting."

Goethe inspected the picture, saw the phenomenon, and explained it. To deepen the hue of the velvet coat the painter had covered it with a special varnish, which, by absorbing part of the water passed over it, was converted into a turbid medium, through which the black behind instantly appeared as blue. To the great joy of the painter, he found that a few hours' continuance in a dry place restored the primitive black. By the evaporation of the moisture the optical continuity of the varnish (to which essential point Goethe does not refer) was reëstablished, after which it ceased to act as a turbid medium.

This question of turbid media took entire possession of the poet's mind. It was ever present to his observation. It was illustrated by the azure of noonday, and by the daffodil and crimson of the evening sky. The inimitable lines written at Ilmenau—

> "Ueber allen Gipfeln
> Ist Ruh',
> In allen Wipfeln
> Spürest Du
> Kaum einen Hauch"—

suggest a stillness of the atmosphere which would allow the columns of fine smoke from the foresters' cottages to rise high into the air. He would thus have an opportunity of seeing the upper portion of the column projected against bright clouds, and the lower portion against dark pines, the brownish yellow of the one and the blue of the other being strikingly and at once revealed. He was able to produce artificially at will the colors which he had previously observed in nature. He noticed that when certain bodies were incorporated with glass this substance also played a double part, appearing blue by reflected and yellow by transmitted light.* The action of turbid media was to Goethe the ultimate fact—the *Urphänomen*—of the world of colors. "We see on the one side Light, and on the other side Darkness. We bring between both Turbidity, and from these opposites develop all colors."

As long as Goethe remained in the region of fact his observations are of permanent value. But by the coercion of a powerful imagination he forced his turbid media into regions to which they did not belong, and sought to overthrow by their agency the irrefragable demonstrations of Newton. Newton's theory, as known by everybody, is that white light is composed of a multitude of differently refrangible rays, whose coalescence in certain proportions produces the impression of white. By prismatic analysis these rays are separated from each other, the color of each ray being strictly determined by its refrangibility. The experiments of Newton, whereby he sought to establish this theory, had long appealed with overmastering evidence to every mind trained in the severities of physical investigation. But they did not thus appeal to Goethe. Accepting for the most part the experiments of Newton, he rejected with indignation the conclusions drawn from them, and turned into utter ridicule the notion that white light possessed the composite character ascribed to it. Many of the naturalists of his time supported him, while among philosophers Schelling and Hegel shouted in acclamation over the supposed defeat of Newton. The physicists, however, gave the poet no countenance. Goethe met their scorn with scorn, and under his lash these deniers of his theory, their master included, paid the penalty of their arrogance.

How, then, did he lay down the lines of his own theory? How,

* Beautiful and instructive samples of such glass are to be seen in the Venice Glass Company's shop, No. 30 St. James's Street.

out of such meager elements as his yellow, and his blue, and his turbid medium, did he extract the amazing variety and richness of the Newtonian spectrum? Here we must walk circumspectly, for the intellectual atmosphere with which Goethe surrounds himself is by no means free from turbidity. In trying to account for his position, we must make ourselves acquainted with his salient facts, and endeavor to place our minds in sympathy with his mode of regarding them. He found that he could intensify the yellow of his transmitted light by making the turbidity of his medium stronger. A single sheet of diaphanous parchment placed over a hole in his window-shutter appeared whitish. Two sheets appeared yellow, which by the addition of other sheets could be converted into red. It is quite true that by simply sending it through a medium charged with extremely minute particles we can extract from white light a ruby red. The red of the London sun, of which we have had such fine and frequent examples during the late winter, is a case to some extent in point. Goethe did not believe in Newton's differently refrangible rays. He refused to entertain the notion that the red light obtained by the employment of several sheets of parchment was different in quality from the yellow light obtained with two. The red, according to him, was a mere intensification—"Steigerung"—of the yellow. Colors in general consisted, according to Goethe, of light on its way to darkness, and the only difference between yellow and red consisted in the latter being nearer than the former to its final goal.

But how in the production of the spectrum do turbid media come into play? If they exist, where are they? The poet's answer to this question is subtile in the extreme. He wanders round the answer before he touches it, indulging in various considerations regarding penumbræ and double images, with the apparent aim of breaking down the repugnance to his logic which the mind of his reader is only too likely to entertain. If you place a white card near the surface of a piece of plate-glass, and look obliquely at the image of the card reflected from the two surfaces, you observe two images, which are hazy at the edges and more dense and defined where they overlap. These hazy edges Goethe pressed into his service as turbid media. He fancied that they associated themselves indissolubly with his refracted rectangles—that in every case the image of the rectangle was accompanied by a secondary hazy image, a little in advance of the principal one. At one edge, he contended, the advanced secondary image had black behind it, which was converted into blue; while at the other edge it had white behind it, and appeared yellow. When the refracted rectangle is made very narrow, the fringes approach each other and finally overlap. Blue thus mingles with yellow, and the green of the spectrum is the consequence. This, in a nutshell, is the theory of colors developed in the "Farbenlehre." Goethe obviously regarded the narrowing of the rectangle, of the cylindrical beam, or of the slit of light passing through the prism, which, according to Newton, is the indispensable condition requisite for the production of a pure spectrum, as an impure and complicated mode of illustrating the phenomenon. The elementary fact is, according to Goethe, obtained when we operate with a wide rectangle the edges only of which are colored, while the center remains white. His experiments with the parchment had made him acquainted with the passage of yellow into red as he multiplied his layers; but how this passage occurs in the spectrum he does not explain. That, however, his hazy surfaces—his virtual turbid media—produced, in some way or other, the observed passage and intensification, Goethe held as firmly, and enunciated as confidently, as if his analysis of the phenomena had been complete.

The fact is, that between double images and turbid media there is no kinship whatever. Turbidity is due to the diffusion, in a transparent medium, of minute particles having a refractive index different from that of the medium. But the act of reflection which produced the penumbral surfaces, whose aid Goethe invoked, did not charge them with such discrete particles. On various former occasions I have tried to set forth the principles on which the chromatic action of turbid media depends. When such media are to be seen blue, the light scattered by the diffused particles, and that only, ought to reach the eye. This feeble light may be compared to a faint whisper which is easily rendered inaudible by a louder noise. The scattered light of the particles is accordingly overpowered, when a stronger light comes, not from the particles, but from a bright surface behind them. Here the light reaches the eye, minus that scattered by the particles. It is therefore the complementary light, or yellow. Both effects are immediately deducible from the principles of the undulatory theory. As a stone in water throws back a larger fraction of a ripple than of a larger wave, so do the excessively minute particles which produce the turbidity scatter more copiously the small waves of the spectrum than the large ones. Light scattered by such particles will therefore always contain a preponderance of the waves which produce the sensation of blue. During its transmission through the turbid medium the white light is more and more robbed of its blue constituents, the transmitted light which reaches the eye being therefore complementary to the blue.

Some of you are, no doubt, aware that it is possible to take matter in the gaseous condition, when its smallest parts are molecules, incapable of being either seen themselves or of scattering any sensible portion of light which impinges on them; that it is possible to shake these molecules asunder by special light-waves, so that their liberated constituents shall coalesce anew and form, not *molecules*, but *particles;* that it is possible to cause these particles to grow, from a size bordering on the atomic, to a size which enables them to copiously scatter light. Some of you are aware that in the early stages of their growth, when they are still beyond the grasp of the microscope, such particles, no matter what the substance may be of which they are composed, shed forth a pure firmamental blue; and that from them we can manufacture in the laboratory artificial skies which display all the phenomena, both of color and polarization, of the real firmament.

With regard to the production of the green of the spectrum by the overlapping of yellow and blue, Goethe, like a multitude of others, confounded the mixture of blue and yellow lights with that of blue and yellow pigments. This was an error shared by the world at large. But in Goethe's own day, Wünsch, of Leipsic, who is ridiculed in the "Farbenlehre," had corrected the error, and proved the mixture of blue and yellow lights to produce white. Any doubt that might be entertained of Wünsch's experiments—and they are obviously the work of a careful and competent man—is entirely removed by the experiments of Helmholtz and others in our own day. Thus, to sum up, Goethe's theory, if such it may be called, proves incompetent to account even approximately for the Newtonian spectrum. He refers it to turbid media, but no such media come into play. He fails to account for the passage of yellow into red and of blue into violet; while his attempt to deduce the green of the spectrum from the mixture of yellow and blue is contradicted by facts which were extant in his own time.

HOW ANIMALS EAT.

By HERMAN L. FAIRCHILD.

IN the digestion of the higher animals, the first act is the trituration of the food to assist and hasten its solution. We might term this mechanical digestion, as it is a reduction of the food preparatory to the essential physical and chemical process. Although very simple in

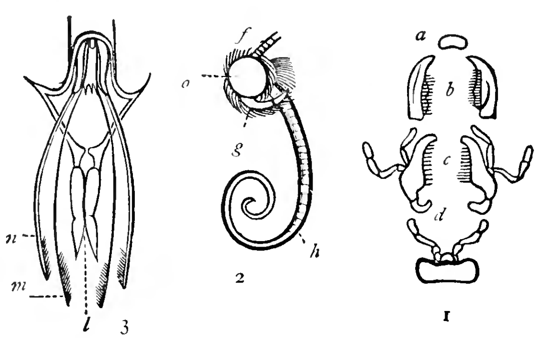


FIG. 1.—ORGANS OF THE MOUTH IN INSECTS: 1. Trophi of a masticating insect (beetle): *a*, labrum or upper lip; *b*, mandibles; *c*, maxillæ with their palpi; *d*, labium or lower lip with its palpi. 2. Mouth of a butterfly: *o*, eye; *f*, base of antennæ; *g*, labial palp; *h*, spiral trunk or "antlia" 3. Mouth of a hemipterous insect (*Nepa cinerea*): *l*, labium; *m*, maxillæ; *n*, mandibles.

purpose, the manner is exceedingly various and interesting. The mastication of food is usually accomplished by a mill in the mouth. And absence of a masticatory apparatus at the entrance of the food-canal is usually compensated by a mill within the body, as the gizzard of a bird, or by strong chemical solvents as shown in the snake.

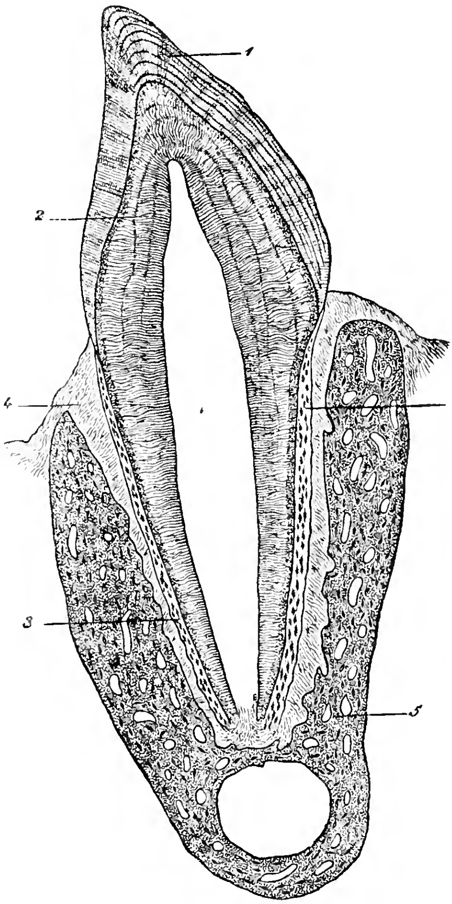


FIG. 2.—SECTION OF TOOTH OF CAT, *in situ:* 1, enamel; 2, dentine, or ivory; 3, cement, or bone; 4, periosteum; 5, bone of lower jaw; 6, pulp-cavity.

To soften the food and so assist in its trituration, nearly all animals are provided with saliva. But, as this fluid serves to lubricate the food for swallowing, and also has a chemical power, it may be considered in connection with digestion.

Those animals which subsist wholly on liquids or on minute particles require, of course, no masticating organs. Of the first class, are most parasites, the butterflies and some humming-birds; and, of the second, bivalve mollusks and the whalebone whale. The little sea-urchin is remarkable as the first animal, and below mollusks and articulates the only animal, possessing any organs for mastication. Furthermore, its dental apparatus is perhaps of greatest complexity in the whole animal kingdom. Five triangular teeth set in as many jaws surround the opening to the stomach, and move toward a central point. They seize and divide the food which then passes between the masticating jaws. The latter are grooved, and, aided by saliva, effectually crush and grind the food. The muscles and levers necessary to efficient action are numerous and intricate, altogether forming an apparatus entirely unique in form and principle.

Among mollusks the gasteropods or snails, and the cephalopods, which include the cuttle- and devil-fishes, have masticating organs. Most snails have thousands of minute teeth on the tongue. These are, however, chiefly used for procuring food by a rasping or boring motion. But some snails, not satisfied with lingual teeth alone, indulge the absurdity of carrying powerful teeth in the stomach. The beak of the cuttle-fish divides the food somewhat, but the masticating process is mainly performed by a gizzard.

Articulates have a much greater variety of masticating organs. Nearly all, even some of the worms, have efficient jaws for seizing food, which also serve to cut and crush the same.

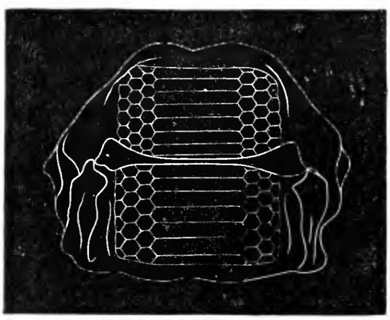


Fig. 3.—Jaws and Pavement-teeth of a Ray (*Myliobates*).

Imagine a creature with so little regard for the proprieties as to chew food with its legs! Yet the common limulus, or "horseshoe crab," actually grinds the food between its thighs. However, this is not so strange, when we understand that the claws of the lobster and crab are simply modified legs; and that many higher animals, the squirrel and cat, for instance, use their feet in eating.

Another group of crustaceans, the little rotifers, pound their food. The lower jaw serves the purpose of an anvil upon which the food is crushed by two hammers formed from the upper jaw. Lobsters and crabs masticate with their horny jaws; but they all have complete and efficient sets of teeth in the gizzard-like stomach. And, when the shell is cast, the teeth are also shed along with the stomach-lining. Those members of the spider and centiped classes which eat solid matter have masticating jaws. But the best development of such jaws is found in the insects. Nearly all insects while in the larval state, and many adult insects, as beetles and grasshoppers, have two pairs of

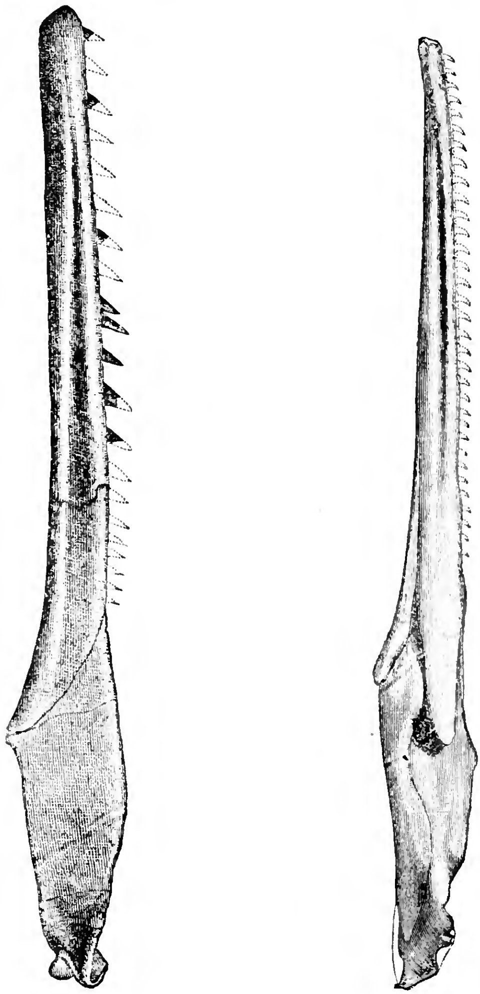


FIG. 4. FIG. 5.

LOWER JAWS OF ANCIENT TOOTHED BIRDS (after Marsh).

Fig. 4: *Ichthyornis dispar*. Twice the natural size. Teeth in distinct sockets. Fig. 5: *Hesperornis regalis*. One half natural size. Teeth set in a groove.

jaws, called mandibles and maxillæ, which move horizontally between upper and under lips. Such insects usually have gizzards to complete the mechanical process. The grasshoppers and others have the gizzard armed with rows of horny teeth. The activity and efficiency of insect-jaws is very great, as many people have the misfortune to know. From before the time of Pharaoh, the biting insects have been a scourge to the farmer. Their voracity is awful; and, when urged by hunger, few substances can withstand their jaws. In countless hosts they ravage a country, and blast it as with the curse of Jehovah. It is stated that some caterpillars eat three to four times their weight of food every day. That beasts like the elephant and tiger are not voracious in proportion to their size is matter for congratulation. Fortunately, however, such ravenous insects eat only in the larval state; for most moths and butterflies exist on love, and none take any more substantial nourishment than the honey of flowers.

The common fly has minute teeth. Many grubs live within trunks of trees, gnawing immense galleries, and subsisting on the wood. The termites, or "white ants," devour whole houses, leaving only a shell fair to all external appearance, but crumbling at a touch. "At Tonnay-Charente the termites, having gnawed away the props of a dining-room without its being perceived, the flooring collapsed during a party, and the entertainer and his guests sank through." The larva of the giant sirex gnaws burrows in lead.

Teeth of mollusks and articulates are usually horny—that is, hardened skin, like the crust of the lobster and beetle. Sometimes they

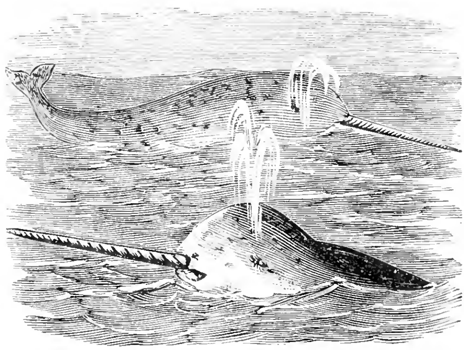


Fig. 6.—Narwhal, or Sea-unicorn.

are calcareous and sometimes siliceous. Those of the vertebrates are complex in structure and substance, and are regarded as the only true teeth. They consist of dentine or ivory, of which there are several kinds. In mammals and the highest reptiles, the dentine is surrounded by a sort of bone called cement; and the surface exposed to wear is capped or otherwise protected by enamel, the hardest of animal tissues. Teeth do not belong to the bony skeleton, but are developed by the lining membrane of the mouth, which, like the lining of the whole food-canal, is only a continuation of the skin. Hence teeth are classed with other skin appendages, as the nails and hair.

The teeth of fishes are extremely various in number, form, structure, and method of attachment. They are almost entirely used for prehension, as nearly all fishes, like reptiles and birds, do not masticate but gulp down their food as quickly as possible. The exceptions, however, are interesting. Some rays and the cestracion of Australia have the jaws filled with teeth, flattened and joined together like blocks in a pavement, or like mosaic. These are used to crush sea-weed and mollusks. In a former geological age, this was the prevailing form of teeth in the whole order of sharks. The common carp has its teeth on the bones of the pharynx, and hence masticates its food in its throat. For this purpose the food is sent back after being swallowed. Some fishes are toothless, but most fishes have hundreds of teeth, frequently covering all parts of the mouth. The teeth of fishes and of reptiles are shed and replaced indefinitely.

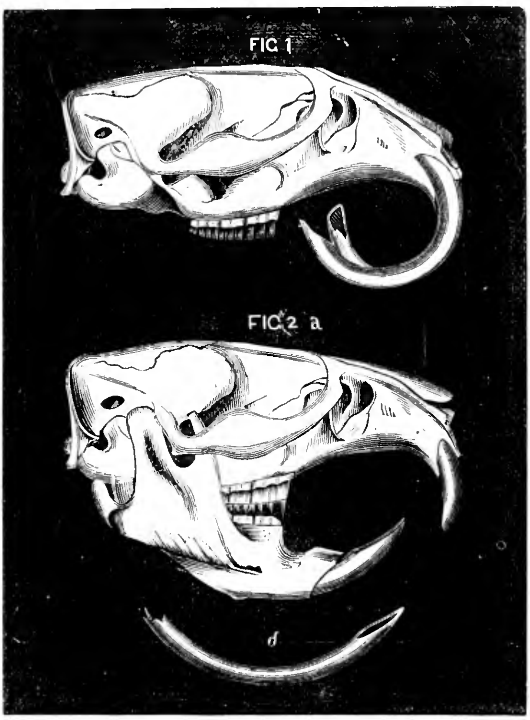


FIG. 7.—SKULLS AND TEETH OF MUSKRAT (*Fiber zibethicus*). Size reduced. 1, cranium with upper incisors overgrown, due to loss of lower incisors; 2 *a*, skull and jaw with normal teeth; 2 *b*, lower incisor removed, to show its great length.

Reptilian teeth present no great variety. Toads, tortoises, turtles, and some lizards are entirely destitute of teeth. Frogs have teeth in the upper jaw. Those of serpents assist in swallowing the huge prey. The poison-fangs of venomous species present a peculiar and complex modification. They are fastened to movable bones which are worked by the muscles moving the jaw. When the mouth is closed, the fangs lie on the gums; but in opening the mouth they are brought into a striking position. The muscles also press at the same time upon the glands which secrete the venom, and force the latter through a deep channel or canal in the fang.

Some birds of ancient times had true teeth placed in sockets in the jaws; but all modern birds depend wholly on the gizzard for mastication. This is literally a mill. It is formed of powerful muscles, has a horny lining, and pulverizes hard grain and indeed almost any substance by rubbing between the tough walls. To assist the grinding, the grain-eaters swallow gravel, bits of broken glass and crockery, metals, etc., which are pulverized in turn. One would suppose such

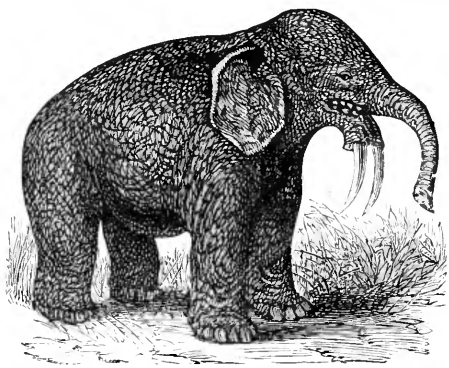


Fig. 8.—Dinotherium Giganteum.

diet would injure the organ; but the tough lining yields without being cut. In birds the gizzard follows the stomach; that is to say, the food is not ground until after it is subjected to the gastric juice. This seems a reversal of the proper order, but the hard grain is more easily pulverized by rubbing after being softened by the solvent fluid. In other animals the gizzard, if a distinct cavity, usually precedes the true stomach. The power of this mill is proportional to the resistance of the food. Thus in flesh-eating birds the gizzard is weak.

Mastication is best exhibited in mammals and is almost entirely by means of teeth. Mammalian teeth are of three kinds: incisors or front cutting teeth; canines, which characterize flesh-eaters; and molars or masticators. They are placed in sockets in the bones, but always in a single row on the outer edge of the jaws, and are never renewed more than once.

The extreme numerical variation of mammalian teeth is found rather strangely in the same group, the order of whales. A river-dolphin of South America has the greatest number, two hundred and twenty-two; while the whalebone whale has no developed teeth, they being replaced with baleen-plates. The narwhal, or sea-unicorn, has, of two in embryo, but a single tooth developed. This, however, is remarkable as being the longest in the animal kingdom. It is the left upper canine, and except in rare cases possessed by the male alone. Instances are recorded where both teeth were developed. This ivory tusk points directly forward in line with the body, perfectly straight, and sometimes attains the length of ten feet. The rough surface is spirally grooved as if the tusk were twisted. Various unsatisfactory conjectures have been offered regarding the object of this strange development; but, beyond its evident use as a weapon, its purpose is still a mystery.

The whole group of ant-eaters, and the sloths and armadillos, are quite destitute of teeth, on which account they are called edentates. Many of them have no teeth whatever; and when teeth are present

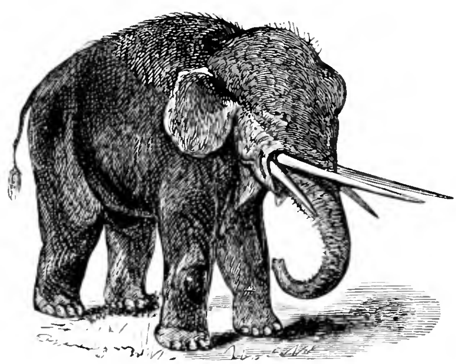


Fig. 9.—Mastodon Giganteus.

they are limited to the back part of the jaws, without enamel and rootless—all of which features help to rank the edentates very low among mammals. In place of teeth, the duck-bill—the lowest of mammals—has four horny plates, two in each jaw.

The average number of mammalian teeth is thirty-two—possessed by man, apes, and ruminants. But, the hog is the happy possessor of the typical number, forty-four; which honor is also shared by the opossum and mole. Man is the only living animal with an unbroken succession of teeth, and having the canines of the same height as the others.

The incisors of rodents are very interesting. They are the only prehensile organs of the gnawing mammals, and are exposed to severe wear. But, as the enamel is thicker and the dentine harder in front, the abrasion constantly produces a chisel-edge admirably fitted for gnawing hard substances. They must, however, be kept of a certain length; and to supply the loss by abrasion they are continually growing out from the base, being supplied by a permanent pulp. Their length in the jaw is great, to insure solidity without actual union with the bone. The loss of an incisor results in the abnormal lengthening of the opposing one, which may finally interfere with mastication and cause starvation. Ruminants have no incisors in the upper jaw; the elephant has none in the lower jaw, but the tusks are upper incisors. An elephantine mammal of former geological time, the dinotherium, had incisor tusks in the lower jaw, pointing down and backward; while the extinct mastodon had tusks in both jaws.

The canines are intended for seizing and tearing prey and especially characterize carnivorous mammals. They are lacking in rodents and most herbivores, and are never more than four in number. In the apes they are very prominent; those of the gorilla nearly equaling a lion's in size. The tusks of the walrus are upper canines, as also are the terrible tusks of the wild hog. In the Malayan hog the upper

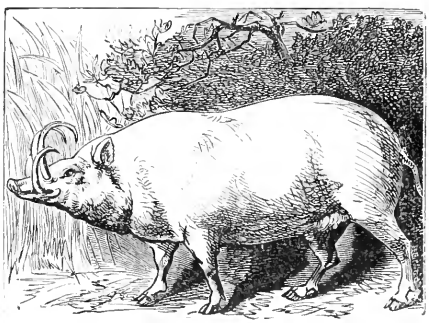


Fig. 10.—Babyroussa, or Malayan Wild Hog.

canines, instead of pointing downward, as would seem proper, grow upward through the integuments of the skull and curve backward, sometimes reaching the skull again. Their purpose is obscure. Although possessed in such degree by the male alone, the form precludes their efficient use as weapons. The lower canines also grow to enormous length and are directed outward, forming weapons which make the beast a formidable antagonist.

Herbivorous mammals have the molars flat on the grinding surface, and the enamel and cement disposed in plates and folds perpendicular to this face. Thus by the unequal wear of the tissues the acting surfaces are ridged and admirably adapted for grinding. They form an actual grist-mill, the stones of which never need any "picking." In fruit-eaters the crowns of the teeth are rounded. Insectivorous mammals have the teeth conical and fitting in opposing depressions. Those living on a mixed diet, as man, have the tubercles or cusps somewhat blunt, and suited either for crushing or cutting. In purely carnivorous mammals the molars have sharp edges fitted for cutting meat. They act like chopping-knives, or more accurately like scissors. Quite the only motion of the jaw is up and down, as flesh can not well be ground. Here we have a genuine "hash-mill." The backward and forward motion of the jaw prevails in the rodents. Other mammals have the lateral motion in a great degree, making three motions. All vertebrates have the jaws opening vertically, while articulates have horizontal jaws, and the sea-urchin has converging jaws.

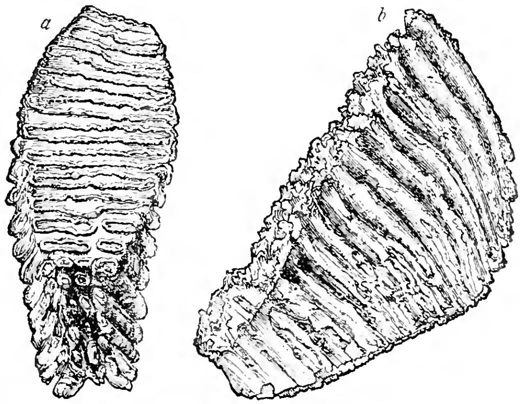


FIG. 11.—MOLAR TOOTH OF MAMMOTH (*Elephas primigenius*): *a*, grinding surface; *b*, side-view.

The harmony and mutual dependence between all parts of an animal's body are not better shown than in the adaptation of the teeth of vertebrates to the kind of food, and their consequent agreement with the habits, structure, and form of the individual. A single tooth frequently reveals the entire character of its possessor. Indeed, no single organ is of greater zoölogical value. Not only does the student of living forms use the teeth as indicative of character and a means of classification, but their superior durability makes them of the very greatest importance in the study of ancient life.

ABOUT CARPENTERS.

By MAURICE MAURIS.

IT is characteristic of architecture that the further back we look toward the primitive state of man, the more the use of wood prevails over that of stone, brick, and all other building materials, and the more does the importance of carpentry exceed that of masonry. The condition of this art might well be taken as the basis of division between the various stages of the civilization of a country. During the first stage, wood is everywhere the only material used in construction ; the second stage is marked by a mixture of wood and ashlar work ; while in the third, or highest stage, carpentry yields constantly to masonwork, until it becomes a mere subordinate agent.

We can imagine man in a savage state. "The penalty of Adam's—the seasons' difference"—was full upon him; at first he crept, like the beasts, within groves and hollow trees, or into dark caves and holes dug in the earth; or else he perched himself, like the birds, in nests built with less skill than those of the swallow or the stork. But necessity is the mother of invention; and the gradual sharpening of his obtuse faculties soon taught man how to procure a better shelter. In the dawn of social impulses, noting the fall of the rain and the sweep of the wind, and feeling the necessity of providing for his own security against the wild beasts; next, deriving some rude ideas of stability from the contemplation of the material world and of the structures instinctively erected by animals, he turned his mind to the construction of dwellings which might afford him real protection, and he availed himself of the materials at hand—the trees by which he was surrounded. The art of building, which has invariably been the starting-point of civilization and the precursor of every species of knowledge, was thus originated. The art of the carpenter is thus the earliest of arts; and the glorious monuments of later ages may, in their main outlines, and even in many of their smaller parts, be traced to the rough wood huts which arose in the wild forests and in the midst of lakes during the prehistorical times.

Like Cuvier, who, out of an age-eaten bone, was able to rebuild the skeleton of a whole fish, paleontologists of our day have, from the scanty remains found in the lakes of Europe, deduced almost to a certainty the characteristics of the lacustrine dwellings which formed the abode of man during the neolithic period of the Stone age. The interest awakened by such discoveries has been so great as to render it wholly needless for us to give a description of the house, bridge, and boat building of prehistoric man. The savages of the present age seem to have been providentially left to confirm the truths which paleontology has endeavored to wrench from the bowels of the earth and the depths of the water; they seem to be left as milestones to indicate the road that mankind has passed over, or rather, as Edmond About says, "They are the stragglers in the army of civilization, by the presence of whom we are informed whence the great body started and whither it went." Reliable accounts of travelers bear witness, in fact, to the existence, even at the present day, of certain Asiatic and Polynesian islanders, who still inhabit wood dwellings erected on piles driven into the water, thus perpetuating a custom prevailing in times beyond record. Herodotus has a passage relating to a tribe that dwelt five hundred and twenty years before the Christian era on Lake Prasias, in Thrace, the modern Roumelia, whose modes of life illustrate those of the lake-dwellers. According to this historian, the Pæonians lived upon the lake in dwellings erected on platforms, which were supported by piles and connected with the land by narrow bridges. They were polygamists, and a law directed that, for each wife, three piles should be added to the structure, thus wisely adding to its security. There was a hut for every family, with a trap-door giving access to the lake beneath. The small children were tied by the foot with a string, lest they should fall into the water.

Hassenfratz took some trouble to ascertain the actual form of the huts of savage tribes of our time. In his book on carpentry he gives thirty-three specimens, of which, however, only sixteen or eighteen were copied from existing habitations, the remainder being derived from detailed descriptions of travelers. The pyramidal form, as the simplest, is that generally adopted by the more barbarous tribes, which fact gives good ground for conjecture that this style of building is the oldest of all. Usually the plan is oblong, though sometimes circular, and the roof is either angular or curved, according as stiff or pliant woods were at hand. In the African *kraals* and similar huts, flexible pieces of wood are bent into a semicircle, and the ends fixed into the ground. Other huts resemble pig-sties, rabbit-bins, and chicken-houses. The Siamese elevate the floor of their cabins some feet above the ground for protection from the damp, and the summer huts of the Kamtchatdales are built on posts and have for an entrance an inclined piece of timber with rough steps, like those in chicken-houses, leading to the roosting-place. This seems to be the primitive idea of building a staircase.

Chinese structures, when compared with those of less advanced nations, are a token of wonderful progress. The Chinese have had regular carpenters from time immemorial, while, among primitive nations, there is no trace of classification of workmen into distinct trades. A species of bamboo is much used by the Chinese; the inner part of this wood being spongy, it is practically a cylinder which does not admit of squaring, but is strong, hard, and durable. The skill of the Chinese carpenters is chiefly demonstrated by their light and elegant bridges, and, if we mistake not, the first idea of suspension-bridges was borrowed from them.

Among no nations of civilized antiquity did carpentry attain so high a development as among the Persians, the Hebrews, and the Phœnicians. With these nations joinery, in the proper acceptation of the word, may be said to have begun, and the progress that this step marked in art is more easily imagined than described. Whatever be the credit accorded to the book of Genesis, it will always remain the most authentic record of the Hebrew nation in Moses's times. The account therein found of the ark is very important in connection with ship-building: if we reflect that the proportions of the ark have been nearly the same as those of modern ship-building, up to the time of the application of iron and steam to navigation, their skill can not but command admiration. From its resemblance to a house, it may also be safely inferred that Hebrew dwellings were divided into stories and rooms and had a sloping roof, which, upon the whole, is essentially the form of modern houses. The knowledge of the Phœnicians concerning geometry and mechanics, as a matter of course, improved their carpentry to such a degree as to make their workmen sought after even by the Hebrews. To Hiram, King of Tyre, both David and Solomon applied not only for materials, but for the greatest number of carpenters he could spare, when proposing to build the Temple of Jerusalem. If we consider what a large share of work carpentry has in establishing a colony and making it prosper, and, again, to what fame the colonies founded by the Phœnicians all along the Mediterranean coast arose, their prominence in this art will be still better proved. A carpenter of Samos, by the name of Mandrocles, perhaps the oldest carpenter whose name has found a place in history, built a bridge on the Bosporus, which, in a few days, afforded passage to Darius and his seven hundred thousand men, when on his expedition against the Scythians.

No documents, to our knowledge, remain that concern the carpentry of the Egyptians. Perhaps, owing to the peculiar conditions of the land, masonry prevailed in Egypt at a very early stage of their civilization; the Pyramids and the temples of Memphis prove, however, better than tongue or pen, what was their knowledge of the art under consideration; those gigantic monuments presuppose the existence of the most powerful machinery. Expressing contempt for any man who by his work contributed, however slightly, to the public welfare, was among the Egyptians, as is known, an infraction of the law, and punishable in consequence. In the case of a young carpenter who had made but a few school implements and had been ill-spoken of, his rights to the public respect were thus solemnly acknowledged by the Magus who sat as judge: "The carpenter who makes school implements accomplishes more toward the improvement of his fellow men than many kings have done."

Vitruvius has speculated at length respecting the form of the early huts in Greece: it appears that they were originally cuneiform; then rectangular, with flat roofs, the boards being well connected and nailed to the posts; later on, the roof became angular, and the hut assumed a shape from which the general outlines of the Doric temple were derived. So enthusiastically was this peculiarly framed roof in former times admired, that even Cicero was betrayed into the unphilosophical remark that, if a temple were to be erected in heaven, where no rain falls, it would be becoming to crown it with a pediment roof. It is hardly needful to explain how the posts were ultimately deprived of their bark, rounded, smoothed, raised on stones and similarly crowned at the summit end, and, to prevent splitting, bound with ligatures at both extremities. "As large trunks," Eny says, "were sometimes difficult to obtain, we note as one of the consequences the petrified bundle-pillar of reeds or sticks tied together at the top and bottom. These most probably suggested the idea of flutes; and the superincumbent pressure, causing a slight swelling in the center, gave rise to the entasis of the column."

With the Greeks and the Romans, carpentry, as well as its sister arts, made great progress, by being applied to war purposes. Military carpenters became the bulwarks of warfare; they were the strategists and pioneers of the time. Be the siege of Troy either history or fable, Homer's accounts prove beyond doubt that the Greeks possessed war-engines contrived with unusual ingenuity: the wooden horse that caused the fall of Troy, and the Argonauts' ship, taking them even as symbols, bear witness to this fact. To any one who, in his boyhood, has perused Cæsar's "Commentaries," the description of the famous bridge thrown by his legions over the Rhine must be still so familiar as to render it useless for us to dwell any longer on this detail. It is evident, however, that in Greece and Rome carpentry, as applied to building, yielded early to masonry. Wood was too soft a material for those sturdy citizens to struggle against; their pride and wealth were too great, their taste too refined, not to prefer the durable and majestic appearance of stone and marble to the perishable littleness of a vegetable matter. Yet, as an art subservient to masonry, carpentry was always up to the standard of the former. But the existence of a perfect system of levers and pulleys, in a word, of all kinds of machinery, may explain the locomotion of those monoliths which are seen standing to this day, like giants among pygmies, at enormous distances from their place of origin. The English are perplexed as to the best means of transporting Cleopatra's Needle to England: Roman carpenters would have deemed it an every-day job!

Had Cæsar taken the same trouble in describing the dwellings of the Gauls as he has respecting their fortifications, war-engines, and ships, an exact idea of their domestic carpentry, at that distant period, would be easily formed. But this not being the case, we can give but very scanty information on the subject. At any rate, the twenty cities of the Biturians, burned down by order of Vercingetorix—the last of the Gauls—were built of wood. In the remote parts of the country which had scarcely any dealings with the invaders, so much is still left of Gallic traditions that, according to Paul Lacroix, it is more than a simple presumption to state that they resembled in shape the rectangular, straw-roofed huts of the modern peasants of northern France, and of the mountaineers of Auvergne. On the other hand, in the merchant cities of the Mediterranean, carpentry was developed in a manner corresponding to their wealth and extravagance. In the interior, numbers of houses were a mixture of wood and stone work, with colonnades and porticoes, which we would liken somewhat to the cottages so common nowadays in this country. The Gauls, too, excelled in military carpentry. When Cæsar threw his legions on their soil, every serious obstacle which he met was due to carpenters. They directed and executed all defense-works; their cities, like Alise, Bourges, and

Namour, had been fortified by carpenters, by means of palisades, and when the Romans attempted to take them by storm, supposing them to be an easy prey, the war-engines of those carpenters hurled them more than once from the top of their ramparts, where they died, at last, like true heroes, for freedom and independence.

The most astonishing progress made by carpentry in ancient times is, in our estimation, that shown by Holland. There man had struggled for ages against the invading waves for the ownership of a land which, in the end, he succeeded in making his own. "Twice a day," the oldest legends tell us, "the ocean extended its empire over the shore with terrible rage, and rose as high as the level of the wooden houses built on immense piles of wood, at considerable distance inland, so that they seemed to float above the water, and their trembling inhabitants could not move around except in boats." This gives an idea how the dwellings of the Hollanders were built, and is an unquestionable token of their skill, as the work of building houses on the sand, supported on piers, and capable of resisting the enormous tides that visit the country, was by no means an easy task; yet they performed still more surprising works: they laid the foundations of those dikes that are reckoned among the greatest works of any description ever accomplished by man.

As has been stated above, in Italy, since the time when Rome was at the height of its glory, masonry, in domestic building, had taken the place of carpentry. But, with the downfall of the empire, when, society being upset, no one could trust in the morrow, and the execution of works which demanded peace and length of time to be accomplished became impossible, carpentry recovered its power; again it controlled architecture and its sister arts, and again it supplied the needs of the barbarians in the savage manner of which it had been formerly divested by civilization. As truly as an epoch of the past can be revived, the primeval ages were called to new life, and with them the primitive systems of construction. Nor could it be otherwise: the savage hordes who now overran Europe felt, thought, acted, and lived as the hordes who had preceded them centuries before. Fortunately, their destructive work did not last long, nor could it extinguish entirely the light that civilization had cast over the land. The conquering races passed away, leaving after them only their good elements—the industrial and agricultural classes—which settled and amalgamated with the indigenes. Carpentry was then called upon to supply new wants. The new religion had grown and spread over the world; it needed oratories and temples; it needed belfries in order that the scattered faithful might hear from afar the consoling sounds which called them to worship. Primitive Christians were neither rich enough, nor sure enough of meeting with tolerance, to undertake the erection of stone buildings. Carpentry supplied their moderate needs. The oldest basilicas were all of wood in the style of that of St. Martin on the ramparts of Rouen, where Meroveus and Brunehilde took refuge to escape the wrath of Queen Fredegonda, and the remains of which were till lately extant. "It was a wooden church," says Augustin Thierry, "the slender frame of which, with its columns formed of several trunks of trees tied together, and its arcades necessarily angular (owing to the difficulty of centering with the materials at hand), that furnished, in all appearance, the type of the ogive or Gothic style which has since played so prominent a part in architecture."

According as the industrial and agricultural colonies led by St. Benedict spread, carpentry enlivened the wilderness of central and northern Europe by constructing those monasteries around which large communities grouped, thus rendering them greater commercial than religious centers. To the carpenters of St. Benedict the establishment of the first manufactories is due as well as the introduction of water-mills, which, though known before, were yet so rare in the fifth century as to make one of them, erected on the river Indre, France, by Ursus, Bishop of Cahors, seem the marvel of the time, and so excite the covetousness of Alaric, King of the Visigoths.

History, always ready to register any deed of princes and courtiers, has rarely preserved any record of the martyrs of labor. In documents discovered and examined with much patience and labor by recent historians, mention is, however, made of a carpenter, by the name of Modestus, who in his time exercised great influence upon the course of events. He lived in Soissons, and, though a plain, unlearned man, he appreciated and honored virtue whenever and wherever he found it. When Gregory, Bishop of Tours, was accused of treason to Queen Fredegonda, by Subdeacon Rikulph, her favorite, and when he was brought to Soissons for trial, Modestus indignantly appealed to the people to defend the saintly bishop, and placed himself at their head. But Rikulph, backed by the Queen's army, caused the poor carpenter to be taken, whipped, tortured, chained, and thrown into a dungeon. Modestus, however, broke his chains and escaped. His escape seemed a miracle, and, as such, it could not fail to affect and embolden the multitude. A conflict was about to ensue, but Modestus deprecated violence and checked the movement. He rushed into the court, by his eloquent pleading persuaded the judges of the bishop's innocence, and exposed Rikulph's iniquity. Gregory was acquitted, but the carpenter, later on, paid with his blood for his love of justice and his opposition to the Queen's favorite.

When cremation of corpses ceased to be a general custom, certain nations intrusted carpenters with the duty of preparing the last dwelling of man. It is not long since quite a number of tombs, perhaps eleven or twelve centuries old, were discovered on the banks of the Danube. They were hollowed out of the trunks of trees, in the form of primeval canoes, to symbolize, perhaps, the last journey of man to unknown regions. We have read somewhere that the tree selected was generally the favorite one of the deceased. How poetical is the destiny of that tree receiving in its bosom the man to whom it had formerly afforded shelter and, perhaps, nourishment!

Between the sixth and the eighth centuries, owing to the increasing activity of the Church in multiplying establishments of all kinds, and to the spreading of agriculture and industry, as well as to the unceasing wars, carpentry had widely enlarged its province. Thus it is not surprising that division of labor was applied to carpentry; and bridge-makers, or "pontiffs," as they were called, after the Latin fashion, builders, joiners, ship-builders and military carpenters were recognized as distinct trades, nor could one division intrude upon the duties of the others.

Though the middle ages are generally estimated as an epoch of retrogression in art, carpentry improved. Its military department was naturally perfected by the unrelenting wars. In these an enormous number of workmen found employment. The battering-rams, the wheeled turrets, and all war-engines received further development. In the ninth century many castles were exclusively made of wood, which proved so strong as to increase the desolation of the invaded countries, for invaders set fire to those they could not take. Such was, in 886, during the siege of Paris by the Normans, the fate of the castle rising on the spot on which the "Châtelet" was afterward built. It was defended by only twelve men; yet the Normans tried again and again in vain to take it, until, tired of their useless assaults, they destroyed it by fire. Byzantine and Gothic architecture, too, becoming bolder, afforded carpentry the opportunity of acquiring an incontestable artistic value; and, if it lost somewhat of its importance in reference to the creation of the great body of a building, it gained ground in the accessories. The interiors of temples and palaces were stocked with furniture; the wooden ceilings were set into compartments of elaborate carvings; the doors divided into panels and ornaments; the cold nakedness of the kalsomined walls was concealed by panels of oak and chestnut, set off in modillions and figures in bas-relief, separated by columns supporting entwined arches. A variety of chests was manufactured; the holy-lofts of churches, as well as the halls of private and public dwellings, were furnished with benches and chairs, previously very rarely seen. All this was, then, the work of carpenters; it was not until later that wood-carvers and cabinet-makers formed a distinct branch of the trade. "Capable, as they were, of accomplishing many more things than the carpenters of our day," Paul Lacroix says, "and being at the same time geometers, constructors, and modelers, the carpenters of the middle ages must be considered rather as artists than as artisans."

About the end of the twelfth century, France having grown tired of war, the throng of pontiffs and carpenters, formerly connected with the armies of the Carlovingian kings, no longer found employment.

Hundreds of those craftsmen, forced by want, swelled the companies of marauders known in history as the "Routiers," "Cottereaux," and "Brabançons." Owing to this reënforcement, their plunderings grew to frightful proportions.

Between the years 1180 and 1182, a pious carpenter of Puy, named Durand, in an outburst of honest and patriotic indignation at sight of the disorders committed by his fellow tradesmen, declared that he had been intrusted by the Lord with the mission of restoring peace. Such was the enthusiasm aroused by his preaching a crusade against the Brabançons, the most terrible of those adventurers, that in a short time he gathered around him a powerful army which were called the "Brothers of the Peace." The Brabançons were exterminated, the other companies having disbanded on learning the successes of the "Pacifics." Durand was hailed as a hero, and the savior of his country. But fanaticism and ambition engendered excess; the Brothers of the Peace became a cause of dread to the community; and France, which, during this moral ebullition, had rejected a part of its impure elements, now cast aside the others, by dispersing the chiefs of the Brotherhood of the Pacifics. Durand, as was often the case under similar circumstances, met with death by order of the powerful lords, for the safety of whom he had worked.

With the organization of commons, carpenters organized themselves in various brotherhoods. Every community was independent, had its peculiar privileges, laws, traditions, and usages. An officer called "Master Carpenter of the King" presided over each one of the French brotherhoods. He was as a brake put to the wheels of the organization by the shy despotism of the monarch. The Church, too, of course, interfered and gave them the character of religious associations. According to the statutes of the Paris brotherhood, carpenters were bound not to work from nine o'clock on Saturday night till Monday morning. The brothers were apprentices or masters. The apprenticeship lasted four years, in the first of which the apprentice was forced to pay his master from one to three farthings per diem. A carpenter could not be compelled to work in the night, except for the royal family and the Bishop of Paris. Every corporation had jurors who were selected among masters having at least ten years' experience, and whose business was to settle, as referees, all questions arising in business transactions. As the choice of materials was of paramount importance for the security of the community at large, it was the jurors' duty to examine all wood before it could be used; the use of wood upon which the jurors had not thought fit to put their seal entailed heavy fines and even the suspension of the transgressor. The purchases of wood made in advance did not bind the carpenter, if the jurors failed to find it satisfactory; on the arrival of the merchandise, too, the purchaser could not take possession of the whole cargo, if his brother-tradesmen were not provided with sufficient materials to go on with work in hand.

Strange as it may appear, this provision was very wise, as it placed public utility above personal interest and prevented monopoly. They had a chapel of their own, where, besides religious affairs, all the business concerning the brotherhood was transacted. There the apprentice aspiring to mastership underwent the practical and theoretical examination on which his fate depended; the work executed by him on the occasion was consecrated to the patron saint of the community.

In connection with the bridge-makers there are some details that we can not afford to omit. These carpenters, during the middle ages, were a kind of nomad tribe, who traveled in companies and pitched their tents wherever their work was required; bridges were built at their risk, and they had no claim to payment until their work had withstood the test of the winter floods. Originally they came from northern Italy, but in the twelfth century a similar association was formed in Germany, which shortly monopolized the trade in northern Europe.

During the thirteenth century, masonry and blacksmithing continued to invade the sphere that carpentry had previously appropriated to itself; the reign of carpenters was over, yet the share of work remaining in their hands was sufficient to enable them to keep step with the artistic and industrial movement of the time. Gunpowder being invented, carpentry, for some time, enlarged its province. The first guns were made of wood, strengthened by bands of iron; new engines were also invented; the reader can imagine who were the first gunners, the first pyrotechnists, and the managers of the *Griète*, as well as of all similar new contrivances.

People acquainted with history will readily understand that a great change must have been operated in carpentry by the civilization of the fourteenth century. In obedience to the laws of evolution and progress that rule the moral as well as the physical world, some provinces of this art were absorbed by superior arts and sciences: some passed under the control of sister arts, others expanded themselves and gained new ground. The carpenter whose bodily strength was overbalanced by the power of his mind was hailed as an engineer or as an architect; the average carpenter remained workman and carried out the ideas of his superiors. This was apparently a fall; yet carpenters made another step forward in the path of progress. The frequent festivals afforded them opportunity to display new talents and skill; descriptions of the festivals of the time may be found in any historical book, which resemble more the tales of the "Arabian Nights" than accounts of real events. During the reign of Louis XIV., a new building—the theatre—was erected; it was made almost entirely of wood, and though in a wholly different order of ideas, carpenters seemed to be inspired in working out the new construction, according to the lofty conceptions by which church-building had been formerly distinguished. Stage carpenters too, accomplished wonders; the illusion was so complete as to make some one say that "stage-carpenters lived an ideal life." Undoubtedly, in a time in which plays dealt so much with the supernatural, playwriters would have done nothing, had they not found full support in carpenters of superior capacity. The name of William Van Schepdael, a carpenter who, assisted by a mason, Henry Vits, covered an arm of the Seine, at Paris, with a vault some thousand yards long, supported by only eighteen hundred wooden pillars, in order to have the space utilized for building purposes, is unknown even to the majority of his fellow tradesmen, but his work remains, and is, even at present, one of the industrial glories of Paris.

In order to avoid repetitions, in connection with the history of carpentry in England, it will be sufficient to state that, begun as anywhere else, it kept step with the development of the country, yet we feel bound particularly to mention English ship-building. The geographical position of the land, which naturally determines its inhabitants' tastes for seafaring, explains the progress of ship-building there. Although the fleets of Pisa, Genoa, and Venice, of Spain and Portugal, had, at different times, won great fame, England eclipsed them all.

It was the privilege of the eighteenth and the nineteenth centuries to fix carpentry on a thorough scientific basis. The works of Monge, his lessons of descriptive geometry ; the profound works of Prony, on statics, hydrostatics, and hydrodynamics ; the researches and discoveries of Lalande, Inghirami, and many others formed a wealth of scientific principles from the application of which carpentry naturally derived unspeakable advantage. Regular schools were founded, among which that of Monge ranks first. Thence have come Krafft, Hassenfratz, Morisot, and scores of carpenters who raised the art to the level of a science.

In several States of the Union the three stages of civilization alluded to in the beginning of our sketch are shown in a striking manner ; there, on the same farm, the log-cabin, the frame-building and the brick house are still frequently seen ; what has been in Europe the work of centuries, here has been that of a generation, and yet it represents an improvement on former work. It is a peculiarity of American frame-buildings to have all the improvements of the best-built stone houses in Europe. Americans have done with carpentry what was before deemed to be a privilege of masonry and iron exclusively. If we dared express our opinion, we would say that, as regards architecture, carpentry is here ahead of masonry. In comparing the pleasant frame-houses of the American farmers with the half-ruined brick dwellings of the French and Italian peasants (who are, however, the most comfortable of European country people), it is to be doubted whether masonry is really indicative of a more advanced civilization. Were we not to make great allowance for the peculiar circumstances in which this country has developed its moral and material faculties, we would solve the question against the generally accepted theory, and proclaim carpentry still the greatest agent of progress. Carpentry in America has not yielded to masonry; even in the erection of brick or stone houses, the former has a greater share of work, the latter doing scarcely anything beyond building the outside walls. In American brick or stone houses, about twenty-five times more wood than in European is used. This may have its evils, wood being subject to ignition and not being naturally so endurable as other materials; but it will not take long for Americans to invent some process by means of which wood may be rendered incombustible, and as solid as stone; something in this direction, we believe, has been done already. The bold centering of domes and the slender elevation of steeples on skeletons of wood, as carried in this country, command the attention of foreigners; there are a dash and lightness in those works that bespeak the skill of American carpenters. The mechanical performances of "Sardanapalus" and other plays can not be overlooked in an article referring to carpentry. Nor can we omit to record that American ship-building compares favorably with that of any nation, the English included. Yet all this becomes a trifle if we consider American wood bridges. The Schuylkill bridge, built by Wernwag at the beginning of this century at Philadelphia—a suspension-bridge, 340 feet long—can not but be considered a marvel of art. This bridge would not yield save under a weight of 1,275 pounds per square inch of the lower chord! During the civil war the constructions of the Federal troops astonished the world; to the rapidity with which new bridges were built in a truly artistic and scientific manner, and to the skill of their architects, engineers, and carpenters is due, in great part, the success of the Northern forces.

Carpenters appear to us as the vanguard of progress, the initiators of all movement toward the supply of mankind's first wants. However incomplete, we trust that our sketch will be deemed suggestive enough to show that their history is worthy of being diffused through the medium of a popular publication.

THE AVAILABILITY OF ENERGY.

By W. D. MILLER, B.A.

IT follows, as a direct consequence of the most usual definition of matter as "the vehicle of energy," and is also arrived at from experience, that energy never does and never can manifest itself except in connection with matter. And, although we could readily conceive of, and in fact see many instances of, matter without energy, yet no person of sound intelligence, or, as said Newton, "no one with a competent faculty of thinking," could for a moment entertain the idea of energy without matter; and we naturally suspect that anything which is so dependent upon another for its existence, as it were, will, in some way or other, mold itself to suit the form and convenience of the other. It thus becomes a question of primary importance as to how energy is connected with and dependent upon matter, and as to how its form and availability are influenced by its connections.

That the same amounts of different kinds of energy, or even of different forms of the same kind, are vastly different in their effects, is a thing of every-day experience. A mass raised above the earth's surface possesses in consequence a certain amount of energy, in virtue of which it can do work; but if it be allowed to fall to the ground under the influence of the earth's attraction, then, although the amount of energy on the earth is neither increased nor diminished, it may be absolutely impossible to gain any work from it. In this instance energy of position is at first transformed into energy of motion, but the moment the mass strikes the ground all motion, as far as we are able to discover, is gone; but we know that the motion of the mass as a whole has only been transformed into motion of the particles among each other, and of the particles of the body on which the mass impinges, constituting the phenomenon of matter commonly called heat. The first two states are available as sources of mechanical energy, but in the third state the energy is scattered into an infinite number of infinitely small energies, as it were, and, in the case of small masses at least, is lost forever as far as doing work is concerned; and so much energy is let down from a high to a low class, and the whole energy of the universe is rendered less available by a corresponding amount.

But not only do equal quantities of energies of different kinds manifest themselves so very differently, but the same is true as to equal amounts of the same kind. A boxer may receive a blow from his antagonist which may stagger him, and perhaps throw him off his balance, but yet do him no permanent injury; while a rifle-ball with half the energy, though it might not disturb his equilibrium, would in all probability inflict instant death. Any number of examples of this kind might be given to show to what an extent the form which a given amount of energy assumes and the constancy of its effects are dependent upon the matter with which it is associated.

Now, the transformability of energy is a measure of its availability, and, in fact, energy is of use to us only and solely because it may be and is constantly transformed (consequently, whatever terms determine its transformability, the same hold good for the determination of its availability).

Since all forms of energy are essentially kinetic or potential, or the energy of heat-motion, it is sufficient if we examine the laws with regard to these.

A body is said to possess *potential* energy when in virtue of its position it *can* do work. A raised weight possesses potential energy, which, by a simple contrivance, may be converted into work; a bent bow and a wound-up spring possess energy of position, because of the separation of their molecules, which we may avail ourselves of by allowing them to fall back into their natural positions.

If a body be allowed to fall, it necessarily loses the energy which it had in virtue of its position as it approaches the ground, but at the same rate it gains a different kind proportional in amount to the space passed through, and consequently to the square of the velocity. In the case of a projectile, or pendulum-bob, there is a gradual transformation from kinetic to potential energy during the ascent, and a re-transformation during the descent. If we spend work in raising a weight, bending a bow, or winding up a spring, that work is spent in laying up stores of energy which we may avail ourselves of at any future time. But if in performing any of these actions we encounter resistance, as in the case of friction, part of the work is spent in overcoming it; and, when we endeavor to get back the energy we put forth, we find that we fail by as much as was spent in overcoming the friction. The energy so spent was long a puzzle to scientific minds, and was believed to be absolutely destroyed, until the experiments of Rumford and Davy fully demonstrated that the work spent in overcoming friction was transformed into *heat*—a form of kinetic energy, it is true, but of such an inferior class as to have entirely escaped the notice of the shrewdest observers. It is, in general, a very easy matter to transform the whole of the potential or kinetic energy of a body into heat; but it becomes quite a different undertaking when we propose to reconvert the heat into either of the other forms.

Carnot was the first who made any progress in the investigation of the subject of the transformation of heat into mechanical energy. His manner of operating was strikingly original and one of great merit, and has assisted wonderfully in the development of this part of science since his time. He established two new and distinct propositions in connection with his method:

1. That we have no right to reason on what has taken place in any series of operations till the working substance has been brought back to its initial state, nor to assign any relation between heat and work by such reasoning.

2. That a reversible engine is the most perfect engine possible. And, consequently, if we possessed a reversible engine, and a condenser absolutely deprived of heat, we could convert the whole of the heat from the boiler into mechanical energy. But since it is impossible to obtain an absolutely cold condenser, there is always a large fraction lost in attempting to convert heat into mechanical energy. Sir W. Thomson, working from the principle laid down by Carnot, found that the heat taken in by a perfect engine is to that given out as the absolute temperature of the boiler is to that of the condenser. He also, carrying the process further, devised a correct proof of Carnot's second proposition, based upon the axiom that "*it is impossible, by means of inani-*

mate material agency, to derive mechanical effect from any portion of matter, by cooling it below the temperature of the coldest of the surrounding bodies."

With the present physical constitution of matter this is true, so far as we are yet able to penetrate at least; but since its constitution might have been such as to render such an axiom null, we purpose to inquire into the physical properties of matter which admit of such an enunciation, and the results which in consequence must be predicted for the present universe.

Let us consider a hot spherical body, whose energy we wish to communicate to another equal sphere, absolutely cold, and suppose for a moment that they have a thin outside crust absolutely impermeable to heat, and that the mass of each sphere is concentrated in a single little ball, to whose motion the heat is due, the ball in the cold sphere will of course lie still at the bottom, while the other is flying about at an inconceivable rate; if, now, the two spheres be brought into contact, and an opening be made between them, in a very short time the ball will undoubtedly pass from the hot to the cold sphere, and thus all the energy will be transferred at once, and, if a movable partition were inserted in the passage, all the heat-energy might be *transformed* into mechanical energy.

If we suppose two balls, instead of one, in each sphere, as soon as *one* passes from the hot to the cold, it will share its motion with the two already there, and one or more of them may pass back before the second has escaped, and thus at once the relations are rendered more complex, and the chance for availing ourselves of all the energy is diminished. If, now, the number of balls becomes infinite, or if we reduce our imaginary spheres to two real spheres, and substitute molecules for balls, then $1 : \infty^{\infty}$ is not an exaggeration of the chance of all the energy being in *one* of the spheres at any time in the future; on the other hand, the continual tendency is to, and the ultimate result is, absolute equality in temperature.

Clerk Maxwell has made the supposition of a vessel full of air, divided into two portions, A and B, by a division in which there is a small hole; and a being, *who can see the molecules*, opens and closes this hole so as to allow only the swifter molecules to pass from A to B, and only the slower ones from B to A. He will thus, without the expenditure of work, raise the temperature of B and lower that of A, in contradiction to the second law of thermo-dynamics.

By the above mode of reasoning, together with the conclusions drawn from our experience of bodies consisting of an immense number of molecules, the result has been arrived at that *the availability of a given amount of energy is determined on a physical basis, and is dependent on the infinite number of particles of which every tangible mass must be composed.*

The instance cited by Professor Maxwell is only "applicable to the more delicate observations and experiments, which we may suppose made by one who can perceive and handle the individual molecules which we deal with only in large masses."

In the *theory* of dynamics we say that action and reaction are equal; and if a body be arrested in the course of any motion, and sent back on its path with exactly the same velocity, it will retrace its path, and at any point of that path it will have exactly the same velocity and the same energy as when it passed through it in the opposite direction. But, *practically*, we are unable to realize such a law, because of the resistances we meet with in friction, electric induction, etc., so that any series of actions taking place in nature is not a reversible one, or the mechanical energy spent can never be wholly restored to its primitive condition. But as a reversible process is the only one which can maintain itself for all time, it follows that our earth is gradually lowering its energy from high to lower classes; the ultimate form to which all must be reduced being that which has its source *not in the position or motion of masses, but of molecules.*

If this process of transformation were not continually going on, our fires would cease to burn, our machines stop working, and all animal and vegetable life would perish. "The whole of active life is simply transformations of energy." Wherever two particles of matter fall together, whenever a drop of rain falls to the earth, whenever an atom of carbon combines with an atom of oxygen in the furnace, we must look upon it as so much energy let down, the greater part of which is dissipated and lost to human good. But it may easily be seen that this degradation of energy is not restricted to the earth alone, for among natural forces we recognize—

1. The energy of fuel, under which we include the energy of food, as being simply the fuel of an animated machine.
2. The energy of a head of water.
3. The natural motions of air and water.
4. The tides and trade-winds.
5. The very inconsiderable mechanical effect derived from the combustion of native sulphur, and from meteoric sources. The first three are wholly due to the sun, and the fourth in part, so that by far the greater amount of our available energy is derived from the sun. "For it is he who separates the carbon from the oxygen of the carbonic acid and enables them to combine again, whether in the furnace of the steam-engine or in the animal body." It is he who sets the air in motion, and raises up the water whose fall is to turn the wheels of our mills. We are thus receiving a constant supply of energy from the sun, and his must be diminished in a corresponding degree.

But, not content with what we receive, we dig down into the bowels of the earth and exhaust our own. There can be no doubt as to the final result to which this universal tendency points. Long after the earth has become uninhabitable, it may be, the kinetic energy of every planet of our system being frittered away into heat by friction on the ethereal medium, they shall find their way, one by one, into the sun's mass, thus giving him the energy by which he will work on for long ages after they are defunct; while he, in his turn, with all his accumulated mass, will precipitate himself into the center of some larger system: and this process will go on till, after various oscillations throughout, perhaps, infinite ages, the whole material universe is accumulated in a single mass, which will then go on radiating its heat into space till it becomes a black, cold, and lifeless mass.

This universal tendency of energy to concentrate, or rather to scatter itself into the least available form, is simply what has been called "*the dissipation of energy*," and may be said to be the complement of *the availability of energy*, and, like it, finds its basis and explanation in that molecular constitution of the material universe which renders it impossible for any amount of energy, which has once distributed itself among the immense number of molecules in any body, ever, of itself, to rise again to a more tangible and available condition.

THE INFECTIOUS AND CONTAGIOUS DISEASES OF CHILDREN.*

BY DR. DELPECH.

THE teacher or director of the school is urged to give immediate personal attention to any child in the school who may appear ill, or who complains of feeling unwell. In such a case the teacher should specially note the presence of one or more of the following signs:

1. Increased temperature of the child's body, discovered by the teacher placing his hand upon the sick child's skin, particularly on the chest, armpit, face, or forehead.
2. Quickening of the pulse, as measured by the aid of a watch, together with hardness of beat.
3. Shivering. Increased or exaggerated sweating, not being the after-result of exercise, etc.
4. Great thirst, with loss of appetite.
5. Tongue more or less white; dry, or red.
6. A flushed or pallid face.
7. Increased or diminished brilliancy of the eye.
8. General weariness and indisposition; sense of fatigue, with aching in the loins; headache; drowsiness or excitement; delirium.

* Instructions regarding the early symptoms of the infectious and contagious diseases of children, prepared by Dr. Delpech for the use of teachers of infant and elementary schools in the Department of the Seine. Abridged and translated by J. Lawrence Hamilton, M. R. C. S.

The majority of the above-named symptoms will almost invariably indicate the presence of a febrile state.

Any child kept at home away from school for a week or more by its parents should, before returning to its school, bring a certificate of health, signed by a duly qualified medical practitioner.

INFECTIOUS FEBRILE DISEASES.—*Small-pox* is rarely found in those schools where vaccination is enforced, as the majority of vaccinated children have not yet lost the protective influence of primary vaccination. Whenever possible, the teacher should have all the children over ten years revaccinated, especially in times of epidemic small-pox. The popular assertion, that, during epidemics of small-pox, revaccination tends further to develop small-pox, is absolutely false.

Small-pox sets in with fever, vomiting, and pains in the loins. After not less than two days, but most frequently on the third day of the illness, there appears—commencing on the face—an eruption of raised spots, more or less numerous, which pass later into pimples or pustules, having a depressed or navel-like center. These spots terminate in scabs, which should have completely disappeared before the child is allowed to return to school. Before readmission to the school the child should have had two or three baths.

Chicken-pox is a mild disease, occasionally preceded by fever. It is characterized by successive crops of *blebs*, preceded by red-colored spots, each new crop being apt to appear toward evening, and is generally accompanied with some accession of slight fever. Chicken-pox is characterized by pea-sized *blebs*, or blisters, filled with a transparent watery liquid, which soon becomes thick, muddy, or bloody, and terminates with scabs. Where the spots on the body are neither numerous nor well marked, the eruption is invariably observed among the hair of the head.

Measles is ushered in with general indisposition, fever, sneezing, weeping, and red eyes, loud noisy cough; occasionally there may be bleeding from the nose and passing diarrhœa. After three or four days' illness, sometimes sooner, an eruption shows itself, first on the chin and face in small, irregular rose-red spots, slightly elevated, which soon spread over the surface of the body, leaving more or less pale, irregular patches of skin unattacked. The complaint is highly contagious. Children with measles, when *kept at home*, and not exposed to the chance of catching cold, generally do well.

Scarlet fever commences with extreme general indisposition, high fever, a dry, burning skin, pains about the throat, and vomiting. Generally toward the end of the first day's illness, sometimes even at the very outset, a child, but a few minutes before in apparent good health, presents itself with a raspberry-red blush or rash, which may either cover the body completely or else appear here and there in patches. The face, the interior of the thighs, the groins, and the neighborhood of the joints are favored situations for the rash. At first glance the eruption looks uniform, but a closer examination discloses innumerable round points, some of which are more pointed and higher than their neighbors, and often run into minute bladders about the size of a pin's-head.

Sometimes the disease is singularly mild ; sometimes exceedingly virulent. Sometimes it is so fugacious that its presence is not suspected until the skin begins to peel, a process notably observed on the hands and feet. Frequently the joints, particularly the wrists, suffer pains analogous to those of rheumatism. Scarlet fever is an extremely contagious disease; and while, after ten days' isolation and the use of a bath at the close, a child convalescent from measles may be allowed to associate with others, not less than six weeks' isolation is required to exhaust the communicability of a case of scarlet fever.

Mumps may come on suddenly, or else be preceded by a few days of general indisposition, which now and then amounts to high fever. A feeling of stiffness about the jaws is soon followed by swelling, often very bulky, and more or less tense. The swelling is apt to extend either at the back of the lower jaw or underneath it. The swelling contains no fluid : dental pain is absent. Generally first one side of the jaw is attacked and then the other; it is rare for both sides to suffer simultaneously. Not uncommonly similiar swellings burst out in other localities of the body, the genital organs being most liable to seizure.

Ulcerative stomatitis is a contagious disease. Its invasion may be preceded by general indisposition, usually unattended with fever. Grayish bleeding ulcers, tending to spread in extent and depth, attack the edge of the gums, the inner side of the cheeks and lips, and the roof of the hard and soft palates, accompanied with an extremely fetid breath.

Diphtheritic sore-throat or croup is eminently contagious. Its approach is insidious, often commencing with some difficulty in swallowing and slight hoarseness. Possibly the glands at the back of the angle of the jaw swell, which in serious cases extends to the neighboring structures of the neck. At other times these symptoms occur subsequent to a swelling about the nostrils, with more or less copious discharge, indicating that the nasal membranes have been seized prior to those in the throat. Cough, if any, is faint and muffled ; the voice is hoarse and smothered.

With a spoon press down the child's tongue, and note if there be any appearance about the tonsils and the soft palate of a skin or leather-like membrane, which may be grayish or whitish, or even blackened by vitiated blood. This false membrane, which characterizes the disease, is prone to spread over the neighboring parts, notably reaching downward into the windpipe. This diphtheritic croup must not be confounded with false or spasmodic croup.

In *false* croup the child has generally been perfectly well during the day preceding the night on which it suddenly wakes up all at once ill with alarming signs of threatening suffocation, attended with loud, clamorous coughing and a clear voice. Here no false membrane is present in the throat, nor are the glands about the jaw swollen. False croup is generally mild, and it is not contagious.

Dysentery may be contagious. It is distinguished by a frequent, sometimes a continual, desire to seek relief in the closet, where in spite even of severe straining the child succeeds in passing only a little slime or mucus, often colored by small quantities of blood. General indisposition and colicky pains in the belly soon compel the child with dysentery to leave the school. To stop infection, no child suffering with dysentery should be allowed to use the general school water or other closet. Dysentery is not to be confounded with diarrhœa, where there are more or less frequent liquid motions.

Typhoid fever is infectious, and is apt to set in or to sneak in with ill-defined signs. For some days the child may have lost its appetite and its general energy, it is fatigued and "done up." Then the fever is next ushered in with great pain, noises and confusion in the head; the hearing becomes obtuse; giddiness occurs, with great difficulty to keep any upright position. There is often bleeding from the nose generally followed up by colicky pains in and swelling of the belly associated with some diarrhœa. The skin is dry, parched and hot; the tongue fouled, with red tip and sides. However, the child before this has been compelled by its state of indisposition to cease attending the school.

Whooping-cough is eminently contagious. The child may be noticed to have had during one or more weeks occasional but violent fits of coughing, which are most frequent during the night. If no complication be present, there is practically no cough between these spasmodic attacks. Usually a short feeling of general indisposition precedes the attack, during which the child in vain struggles to suppress the cough about to burst, when all at once the trunk and frame are subjected to a violent series of successive throbs almost threatening suffocation. At this epoch a few deep drawings-in of the breath are followed by a whistling and almost convulsive inspiration, which may again be succeeded by boisterous coughing. Then in most cases, after a brief moment's repose, a second but a less severe and a shorter onslaught than the first is noticed. Lastly, the fit is terminated by the child's partly spitting and partly swallowing some thick mucus, often at the same time vomiting up any matter present in the stomach.

The time occupied by these seizures to their termination by expectoration varies from sixteen seconds to a couple of minutes.

Owing to the grave and fatal complications often associated even with apparently mild cases of whooping-cough, most especially in very young children, immediate isolation of the sufferer from its schoolfellows is necessary.

Ophthalmia.—Both catarrhal and purulent ophthalmia are highly contagious at all ages, but especially in very young children, and the last-named disease may cause the loss of one or both eyes.

The eyes and their lids become red, swollen, and bathed with a discharge often more or less offensive.

Contagious Parasitic Diseases.—*Itch* is characterized by the appearance of minute transparent vesicles, which occasion the most lively itching, particularly at night-time. The spaces between the toes and fingers, and the wrists, are most liable to invasion. The child's frequent scratching soon converts the rash into scabs, in which condition the disease will frequently first be noticed by the teacher.

The itch is caused by an insect (*Acarus scabei* or *Sarcoptes*) which is nocturnal in its habits and movements. Though highly contagious, the itch can be cured in a few hours.

Crusted ringworm, or *Tinea favosa*, is caused by a vegetable parasite frequenting the scalp, although it may visit other parts of the body which are covered with hair or down. The hair becomes thin and fragile, with loss of its original color ; then follow irregular, unequal, puckered, crust-like yellowish scabs, which may be single or may cover the entire scalp. The scabby flakes in drying and dying crumble to minute fragments, and as dust propagate and disseminate the disease. Itching being frequent in scalp ring-worm, the child's scratching increases the destruction and pulverization of the scab, and thus increases the chances of contagion to others.

The heads of such children as suffer from the disease have a peculiar fetid odor resembling that of a cat's urine. Till quite cured, every child suffering from *favus* should be separated from its schoolfellows, and only be readmitted on presenting a proper medical certificate.

Common ringworm, or *Tinea tonsurans*, is very contagious, making itself manifest by the hair of the head becoming thinner, more fragile, less colored than the surrounding hairs. The affected hairs are apt to turn reddish or ashy-gray ; they seem as if evenly and artificially clipped off at a distance of say $\frac{1}{14}$ to $\frac{1}{8}$ of an inch above the level of the outer layer of the skin. The surface of the patches is rough, irregular, shaggy, covered with a grayish, scurfy powder of a slightly bluish tinge. The diseased places may be one or more in number; the form is circular, varying in size from that of a silver florin to a crown-piece. By the fusing together of several of such parasitically affected localities the greater portion of the scalp may become affected.

Ringworm with Baldness of Scalp (*Tinea decalvans*).—This contagious complaint declares itself by the presence of defined patches naked of all traces of hair having a glistening ivory whiteness not unlike a scar without depression. Their size varies from that of a silver threepenny-piece upward.

Previous to the loss of hair there may have been considerable itching. The eyelids and other parts of the body covered with hair or down may also suffer from the vegetable parasite causing the disease (*Microsporon Audouin*). In children and adults with thick hair this disease may remain long undetected.—*Practitioner.*

THE RATE OF ANIMAL DEVELOPMENT.

By J. W. SLATER.

"Consider young ducks."

ONE of the attempts which have been made to establish the existence of a "great gulf" between man and beast may be pronounced exceptionally curious as an instance alike of careless and defective observation and of rash conclusions. That by such arguments men of eminence could really mislead themselves, and succeed for a length of time in misleading the outside public, is deeply humiliating. Professor St. George Mivart suggests* that a book should be written on the "stupidity of animals." We are far from denying that such a work would be useful; but, should the needful companion volume on the "stupidity of man" make its appearance in due course, it might not unfittingly open with the reasoning we are about to quote.

To begin, then: the slow bodily development of the human infant and its prolonged helplessness are matters far too familiar to require proof, or even illustration. No less familiar and universally admitted is the rapidity with which foals, calves, lambs, kids, chickens, and ducklings acquire the use of their limbs and other organs. These facts could not fail to come under the notice even of the most careless observers. But, who could have imagined that the said facts would be, without further inquiry, at once seized hold of as a theme for stilted declamation, and be elevated to the rank of a fundamental distinction between man and the lower animals? Yet this strange error has actually been committed, not merely by men of words, like Addison, Paley, and Whewell—which is surely sad enough—but even by a man of things, like Sir Humphry Davy. The great chemist attempts to show that man does not use his limbs instinctively, like other animals. Says he:

"Man is so constituted that his muscles acquire their power by habit,† but in the colt and the chicken the limbs are formed with the power of motion, and these animals walk as soon as they have quitted the womb or the egg.

* "Lessons from Nature."

† To speak of acquiring a power by habit is scarcely rational. The power must exist before the habit can be formed.

"*Physicus.* I think I have observed that birds learn to fly and acquire the use of their wings by continued efforts in the same manner as a child does that of his limbs.

"*Ornither.* I can not agree with you. Young birds can not fly as soon as they are hatched, because they have no wing-feathers; but, as soon as these are developed, and even before they are perfectly strong, they use their wings, fly, and quit the nest without any education from their parents." *

Very similar assertions are found in a laborious attempt made by the late Professor Whewell † to set aside the palpable fact that man, like every other animal, has an instinctive—or we might perhaps better say an hereditary—knowledge of the functions of his voluntary organs.

Said the Professor: "The child learns to distinguish forms and positions by a repeated and incessant use of his hands and eyes; he learns to walk, to run, and to leap by slow and laborious degrees; he distinguishes one man from another and one animal from another only after repeated mistakes. Nor can we conceive this to be otherwise. How should the child know at once what muscles he is to exert that he may stand and not fall, till he has often tried? How should he learn to direct his attention to the differences of different faces and persons till he is roused by some memory, or hope which implies memory? It seems to me as if the sensations could not, without considerable practice, be rightly referred to ideas of space, force, resemblance, and the like. Yet that which thus appears impossible is, in fact, done by animals. The lamb, almost immediately after its birth, follows its mother, accommodating the action of its muscles to the form of the ground. The chick just emerged from the shell picks up a minute insect, directing its beak with the greatest accuracy. Even the human infant seeks the breast and exerts its muscles in sucking almost as soon as it is born."

So, after all, "that which thus appears impossible" is, in fact, done not by "animals" only, but by man also! The concession contained in the last sentence is simply fatal to what has gone before. To be consistent the learned Professor ought by all means to have asserted that an infant learns to suck only "by slow and laborious degrees," and after its sensations have been rightly referred to appropriate "ideas." It would scarcely be a more unwarrantable assumption than those he has indulged in abundantly in the course of his argument.

In the same vein as Davy and Whewell, teleologists and natural theologians, when enlarging upon the marvels of instinct, have seldom failed to "trot out" the colt, the calf, or the lamb, to invite our consideration to the chickens and the "young ducks," and to erect upon the precocity of these creatures—as compared with the tedious devel-

* Collected "Works," vol. ix. "Salmonia," p. 105.

† "Philosophy of the Inductive Sciences," ii., p. 616.

opment of our own species—a fancied wall of demarkation between man and beast. Had they been really actuated by a scientific spirit, they would have felt it their bounden duty to ascertain whether *all* the lower animals were, in contrast to man, able to use their limbs soon after their birth. Had they done so, they might have met with evidence similar to what is thus given by an actual observer* in describing an infant orang-outang which had come into his possession: "The Mias, like a very young baby, lying on its back quite helpless, rolling lazily from side to side, stretching out his hands into the air, wishing to grasp something, but hardly able to guide its fingers to any definite object, and when dissatisfied opening wide its almost toothless mouth, and expressing its wants by an almost infantile scream. . . . When I had had it for about a month it began to exhibit some signs of learning to run alone. When laid upon the floor it would push itself along by its legs, or roll over, and thus make an unwieldy progression. When lying in the box it would lift itself up to the edge into almost an erect position, and once or twice succeeded in tumbling over."

Thus we see that, the nearer brutes approach to man in their structure, the more gradual is their development. The process which in the colt and the lamb is contracted so as to escape observation is here shown at very considerable length. That the child, especially in the higher races of mankind, makes a still more gradual progress, is plainly a mere question of degree.

The young ape which Mr. Wallace observed was, beyond all reasonable dispute, acquiring the use of its limbs precisely in the same manner as a human child. If the latter learns, by slow and laborious degrees, what muscles he must exert in order to effect any desired movement, so does the young ape. If the child can not judge of the position and distance of objects, till it has by considerable practice learned to refer its sensations to appropriate "ideas," the same must be said of the young Mias. But, if the young apes, and, indeed, all other young animals, inherit from their forefathers a latent knowledge of the use of their organs, which is called into activity as soon as their muscular and nervous systems are sufficiently developed, the same holds good of the human infant.

Of course, it would be unfair to demand of such men as Professor Whewell that, before theorizing and dogmatizing, they should go forth to the forests of Borneo in search of facts. As for Davy, his splendid achievements in chemistry may cover his failure in biology. But surely every man in Europe, though he may never have met with infant apes, must have seen how kittens, when beginning to walk, totter, stagger, and roll over, just like young children; how they pat at, and endeavor to touch, objects beyond their reach; and how, even after the forelegs have gained a considerable degree of firmness and obey volition, the hinder extremities remain feeble, and are often for

* A. R. Wallace, "Malay Archipelago," p. 45.

a time trailed helplessly along. Thus, then, we see that in the mammalia, instead of man standing alone, sharply contrasted to the rest of the class, he merely occupies one extremity of a series toward the other end of which stand our much-talked-of friends the lamb and the foal, while the carnivorous animals and the apes occupy intermediate positions. Some very plain reasons why this should be the case will follow in due course.

But what are the facts concerning birds? Are they all able, as soon as hatched, to direct the beak with perfect accuracy, to select suitable nourishment, and to flutter about awaiting merely the growth of their wing-feathers before they can take flight? Davy's "Ornither" must have been either a willful sophist or a most egregious goose. Had he been an accurate and conscientious observer, he must have been aware that what he predicates of birds in general is true, in any sense, merely of the Gallinæ, Grallæ, Anseres, and Struthiones, and assuredly not of the Passeres, Picariæ, Columbæ, Psittaci, and Raptores. Did any of the authors to whom we have been referring, before indulging in platitudes on young ducks, ever take the trouble to "consider" young hawks, young thrushes, or young canaries? Had they done so they would have seen that such nestlings, instead of being able to "direct the beak with the greatest accuracy," can merely sit in the nest with open mouth waiting to be fed! A young canary, so far from being able to stand or walk, seldom fails to break its legs if startled and induced by fright to attempt leaving the nest. Such facts as these are known to every bird-fancier—nay, we might say to every rustic youth, who has ever robbed a nest and has attempted to bring up the callow young by hand. They are not known, it appears, to men of erudition. It was, we think, the Prime Minister of Gustavus Adolphus, of Sweden, who said to his son, "Thou knowest not with how little wisdom the world is governed." In like manner, and even more truth, it might be said that we know not with how little accurate thorough knowledge books are compiled, the world is misinstructed, and imposing reputations are built up.

We do not demand original observation from Professor Whewell. Every one knows that the possessors of inherited wealth are apt to despise the man who has acquired a fortune by his own exertions. But there is a class of men—more numerous, we fear, in England than in any other civilized country—who, with a still more unjustifiable prejudice, contemn all knowledge that has not been derived from books, and scorn original research and discovery. Still it is strange that none of these writers should have met with the following observation from Gilbert White:* "On the 5th of July, 1775, I again untiled part of the roof over the nest of a swift. The squab young we brought down and placed upon the grass-plot, where they tumbled about and were as helpless as a new-born child. When we contemplated their

* "Natural History of Selborne," Letter XXI.

naked bodies, their unwieldy, disproportionate abdomina, and their heads too heavy for their necks to support, we could not but marvel."

Davy and Whewell might, further, have found in Erasmus Darwin's "Zoönomia"* some remarks on the different stages of maturity which animals of different species have reached when they are first brought into the world. The author uses these very words: "The chicks of the pheasant and the partridge have more perfect plumage, more perfect eyes, and greater aptitude for walking, than the callow nestlings of the dove or the wren. It is only necessary to show the first their food and teach them how to pick, while the latter for days obtrude a gaping mouth." Would it have been too much trouble for a man of such extensive reading as Professor Whewell to have run his eyes over the passage above quoted? Being, moreover, a German scholar—at least to the extent of an occasional mistranslation from the language—the Professor might have read that Lorenz Oken divided the class Birds into two main subdivisions, nest-sitters and nest-quitters (*nest-hocker und nest-flüchter*), according as when hatched they remain helpless in the nest, or are at once able to run about and seek food for themselves.

Davy, by the mouth of "Ornither," gives a very lame explanation of the fact that the majority of birds can not fly as soon as hatched. Before they can take flight they have to await not alone the growth of their wing-feathers, but the simultaneous development of the muscles. The Raptores, Passeres, etc., are, as we have already seen, unable to walk as well as fly. Does this inability depend upon the want of feathers? The fact that parent-birds educate their young is clearly established by the interesting observations of Dr. C. Abbott.†

In the case of birds of prey the process of education is somewhat prolonged, even after leaving the nest. It is thought by many that Deuteronomy xxxii., v. 11, is a description of the manner in which eagles train their young to fly; "stirring up" the nest, i. e., shaking and disturbing it so as to compel the nestlings to leave their cradle; "fluttering" over them "and bearing them on her wings"—that is to say, following and intercepting their downward movement, and aiding them to reascend.

Thus we see that the condition of the young of the lower animals is, after all, analogous to that of the human infant. The child, indeed, is still slower in learning to walk than the kitten or the young ape, not because he has to learn in a different manner, but because the development of his muscles and joints is much more gradual; because his head is relatively heavier; because he has to support himself on one pair of limbs only, thus rendering his base much narrower and his center of gravity higher from the ground; and because, as we have already pointed out in the case of the kitten, the hinder extremities gain strength more slowly than the anterior.

* Vol. i., pp. 187–194.

† "Quarterly Journal of Science," vol. vi., p. 361.

Surely, therefore, the helplessness of the human infant can no longer be regarded as an exceptional phenomenon, and all conclusions based upon it by rhetoricians may be safely dismissed to dream-land, whence they came.—*Journal of Science.*

ARTIFICIAL DIAMONDS.

THE world of science and the world of fashion are so far removed from each other that they are seldom stirred by the same event, but the production of artificial diamonds has lately startled both these distant realms.

Mr. Hannay, of Glasgow, has recently exhibited before the Royal Society certain crystals which are no accidental productions, but direct results of a process conceived for a definite end. These have been examined by analysts like Professors Maskelyne, Roscoe, and Dewar, and declared to exhibit all the physical and chemical properties of true diamonds.

Mr. Hannay's gems are very small ; but whether he will hereafter succeed in producing large stones, and what effect success of this kind would have on the value of the diamond, we do not propose to inquire. This is a question which concerns the world of fashion alone ; the world of science is interested in asking by what means the crystallization of carbon has at length been accomplished.

Every one is acquainted with the various forms of the substance called carbon. It constitutes a large proportion of all animal and vegetable structures, and we know it best in an impure condition as coke or charcoal ; but it occurs crystallized, and in a state of purity, in two very different forms, viz., diamond and plumbago, or black-lead.

Those bodies which resist all attempts of the chemist to resolve them into simpler forms of matter are called elements, and among the vast number of substances composing our earth some sixty-four, which are for the most part metals, are simple bodies ; of these carbon is one.

Almost every substance which is capable of existing in the solid state assumes, under favorable conditions, a distinct geometrical figure. This power which bodies possess of taking on definite forms is called crystallization, and its most beautiful examples are found among natural minerals, the results of exceedingly slow changes occurring in the substance within the earth. Artificial crystals may be obtained from solutions, by fusion, and in the passage of bodies from the gaseous to the solid condition. Thus crystals of common salt are formed by the evaporation of brine ; many metals, as iron and bismuth, crystallize on cooling after being melted ; and the vapors of some substances, like iodine, for example, deposit crystals in the act of condensation.

Every body possesses its own distinct crystalline form ; every crystal is a geometrical figure, usually bounded by plane surfaces having angles of constant value, and the science of crystallography teaches us to distinguish substances by the measurement of these angles. It is invariably found that artificial crystals which have been deposited slowly and quietly surpass in size, regularity, and beauty those of more rapid formation ; hence it is conjectured that natural minerals owe their great perfection to very gradual deposition in the rocks within which they are found.

Under different conditions the same substance sometimes assumes two crystalline forms, of which somewhat uncommon phenomenon carbon furnishes an example by crystallizing now into diamond, and now into graphite, or plumbago.

Although found in every quarter of the globe, the diamond is the rarest as it is the hardest known mineral. It occurs exclusively among gold-bearing rocks, or sands derived from gold-bearing rocks, and among strata which, though originally soft, shaly deposits of sand or mud, have been "metamorphosed," as it is called, into hard crystalline schists. It was once supposed by geologists that the metamorphic rocks were deposited in their existing crystalline form from a boiling ocean enveloping the still heated globe ; but it is now known that these formations were originally deposited as mud or sand, and have been transmuted into schists by the influence of subterranean heat acting under great pressure, through lengthened periods of time, and aided by thermal water or steam permeating the porous rocks and giving rise to various chemical decompositions and new combinations within them. The diamond probably originates, like coal or mineral oil, from the gradual decomposition of vegetable or animal matter ; we may therefore regard the brilliants which we prize in the drawing-room as having been slowly elaborated from carbonaceous matter furnished by some dead fish, or rotting plant, originally buried in the mud of an inconceivably ancient palæozoic shore.

It will now be seen that, in order to produce the diamond artificially, some means must first be devised whereby the element carbon, which will dissolve in no liquid and vaporize in no flame, can be rendered soluble or gaseous, from either of which conditions it might then probably be recovered in a crystalline form, as happens in the case of other bodies.

Mr. Hannay's attempts to crystallize carbon originated from a research of a very different character. Water, as we all know, vaporizes at a heat of 212° Fahr., and in the same way every liquid has its "boiling-point," or temperature at which it ceases to be a fluid and becomes a gas. Little is known about the condition of matter immediately beyond the "critical point," as the moment of passage from the liquid to the gaseous state is called ; and while investigating this subject it occurred to Mr. Hannay that some insight might be gained into a state of things then so obscure as to be thought hopeless, by dissolving in the liquid under examination some solid substance which fused at a temperature much above the critical point of the fluid.

Sulphur, for example, melts at 111° Fahr., and is soluble in carbon dioxide, a liquid whose boiling-point is 42°. When such a solution was vaporized it was found that the sulphur was not deposited, but remained diffused in the atmosphere of dioxide vapor; or, in other words, the sulphur was dissolved in the gas. If the side of a tube containing such a gaseous solution of sulphur is approached by a red-hot iron, the part next the source of heat becomes coated with a crystalline deposit, which redissolves into the gas on the removal of the heat. In the course of his experiments on the solubility of solids in gases Mr. Hannay further noticed that many bodies, such as alumina and silica, which, like carbon, are insoluble in water, dissolved to a considerable extent in "water-gas," or water at the critical point when it is neither a true liquid nor a true gas. This fact suggested to him that a solvent might even be found for the hitherto insoluble element, carbon; and, as gaseous solutions were found to yield crystalline solids in almost every case upon the withdrawal or dilution of the solvent gas, it was hoped that, from such a gaseous solution of carbon, crystals of diamond might be obtained.

After a large number of experiments, however, it was found that neither charcoal, lampblack, nor black-lead would dissolve in the most probable solvents when these were brought to their critical points, and a new road out of the difficulty had accordingly to be sought.

Chemists have long known that what is called the "nascent" state of matter is one very favorable to chemical combination. Thus nitrogen, for example, refuses to combine with hydrogen, but, if these two substances are simultaneously liberated from some previous combination, they unite at the moment of birth with the utmost ease. Bearing this in mind, it was ascertained that, when a gas containing both carbon and hydrogen is heated under pressure in presence of a metal, the hydrogen is attracted by the metal and the carbon left free.

Mr. Hannay attacked this nascent carbon with many gaseous solvents, and it is his triumph to have found what he sought. In doing so, he has removed a reproach of long standing from the science of chemistry; for, whereas the larger part of that science is occupied with the chemistry of carbon and its compounds, this element has never previously been either dissolved or vaporized by man.

What the solvent is, we are not at present definitely told; we only know that it is some nitrogen compound, probably a cyanide; but the process is quite intelligible in the absence of this information, while its products are open to the examination of experts.

A hydrocarbon vapor, such as petroleum, is decomposed at a high temperature and under great pressure. As the hydrogen and carbon part company, the former is absorbed, while the latter, being nascent, dissolves in a gaseous solvent, from which solution of carbon crystals are then obtained, just as table-salt is produced by the evaporation of brine, and these crystals are diamond.

The temperature at which the dissociation of the hydrocarbon is effected must be very high, and the pressure enormous, so that the great difficulty of the process lies in the construction of an inclosing vessel strong enough to withstand the combination of heat and disruptive force. Coiled tubes of wrought iron, of half an inch bore and four inches external diameter, have been torn open in nine cases out of ten.

The mineralogical tests which demonstrate the genuineness of diamond are as follows: It must scratch topaz and sapphire, its angles must be those of a regular octahedron, it must burn without leaving any residue, and it must exert little or no action on polarized light. Professor Maskelyne, of the British Museum, has already stated in the "Times" that Mr. Hannay's crystals satisfy all these tests. They score topaz and sapphire easily and deeply; the angle of their cleavage-faces, which could not be measured with great accuracy on account of the minuteness of the gems, is 70° 29′, while that of the diamond is 70° 30′. Particles ignited on platinum glow and disappear exactly as the gem would do, and they are very nearly inert in polarized light.

It is not long since science rejected the claims of another Glasgow investigator to the artificial production of crystalline carbon, and it is somewhat singular that Mr. Hannay's successful solution of this great chemical problem should have followed so quickly upon Mr. McTear's failure.

That the diamonds in this case are real there is now no question; and it is quite possible that, just as experience has taught chemists how to produce large and perfect crystals from solutions which under ordinary treatment yield only small and imperfect specimens, so Mr. Hannay may by and by succeed in making diamonds as big as the Koh-i-noor or the Regent.

We learn, however, from the investigator's own statement, that up to the present time it has cost him five pounds to produce five shillings' worth of diamond; but, even if the world of fashion is destined to deplore the degradation of its cherished gem, we may be sure that, long after some new toy has satisfied society for its loss, the crystallization of carbon will possess for the greater world of science the same kind of interest as clings around the discovery of oxygen by Priestley, or the demonstration of magneto-electricity by Michael Faraday.—*Belgravia.*

SKETCH OF PROFESSOR OTTO WILHELM STRUVE.

By Professor SIMON NEWCOMB.

OTTO WILHELM STRUVE, now Director of the Pulkowa Observatory, was born at Dorpat, Russia, May 7, 1819. His father was Dr. Wilhelm Struve, Director of the Dorpat Observatory, and one of the most distinguished of European astronomers. While the son Otto was still a youth, the father imbued the Emperor Nicholas, whose confidence he enjoyed in a high degree, with the notion of erecting the greatest observatory in the world, and thus adding to the luster of his reign and associating his name with the history of science. Thus arose the great Observatory of Pulkowa, some twelve miles south of St. Petersburg, which has sometimes been called the astronomical capital of the world. The work of erecting the observatory, constructing the instruments, and getting the whole established and at work, occupied the years from 1835 to 1840. On the removal of the family to the new establishment, Otto, although only a little over twenty years of age, commenced work as an assistant to his father. His first serious work was an examination of all the stars in the northern heavens, made with the great refractor, in order to detect new double stars. The result was a catalogue of many hundred double stars, all before unknown, and many very close and difficult. The subject of double stars was one which seemed to belong especially to the Struve family, their observations and measurements having been at Dorpat the great work of the father, who thus became preëminent in this branch of research. His "Mensuræ Micrometricæ" is one of the standard astronomical works of the century, a book whose magnificent proportions correspond to the labor expended in its preparation. The next considerable work of the son, and one which has been of enduring value, was a determination of the constant of precession, or, to speak more popularly, of the annual amount of motion of the equinox among the stars. His result has been the accepted standard for thirty years, and the work won the gold medal of the Royal Astronomical Society in 1850.

In 1847 and 1848 he made a series of observations of the satellites of Uranus and Neptune with the great equatorial. His observations of the satellites of Neptune gave the first mass of that planet, which was received with much confidence, but the very unfavorable situation of the planet rendered the result more erroneous than was at first supposed. It has since been proved that the observations made about the same time by Bond, at the Harvard Observatory, gave a result much nearer the truth. While on this work he commenced a search for the inner satellites of Uranus, which had been suspected by Sir William Herschel, but have since been proved not to exist. He succeeded, however, in making several observations of what he at the time supposed to be a new inner satellite, but did not succeed in getting a sufficient number to establish the orbit. The existence of two inner satellites has since been established, and it is probable that Struve's observations were sometimes on one of them and sometimes on the other.

The field covered by Struve's subsequent labors is so large and his papers so numerous that it is not easy to give any untechnical account of his works. He has determined the parallax of several stars, made a careful series of observations on the rings of Saturn, made several journeys to observe solar eclipses, and had general charge of the geodetic operations in the Russian Empire. His greatest recent work has been a continuation of the work of his father on double stars. In 1878 the observations of this class, which he had been making for thirty-five years, were all collected and published in the ninth volume of the "Pulkowa Observations."

In 1862 he succeeded his father as Director of the Pulkowa Observatory. Since that time his energies have been as much occupied with the general direction of the establishment as with independent scientific work. His family has been distinguished by the managing capacity and diplomatic skill of its members, some of whom hold high positions in the civil and diplomatic service of the Government. The subject of our sketch is, in this respect, not inferior to his relatives; and the great efficiency which the observatory has attained under his direction is due as much to his cautious temper, good sense, and judicious management, as to his scientific ability.

The last enterprise undertaken by Struve is of special interest to us. For many years the great telescope at Pulkowa, and its brother instrument at Cambridge, both of fifteen inches aperture, were the largest successful refractors in the world. With the construction of the eighteen-inch telescope for Chicago in 1862, the introduction of larger instruments was inaugurated and continued until the great Washington telescope left that at Pulkowa far behind. This was so far contrary to the ideas of the Pulkowa Observatory that about a year ago the Russian Government authorized Struve to negotiate for the construction of a larger refractor than any yet made. The most difficult and delicate matter was the objective, and, after a visit to the principal European workshops, he determined to come to America for the purpose of conferring with Alvan Clark and Sons, and inspecting their *chef-d'œuvre* at Washington. On arriving here in August last he spent several weeks in visiting friends and institutions. At the Saratoga meeting of the American Association for the Advancement of Science, he had an opportunity of making the acquaintance of many of our scientists. The result of his visit to Cambridge was the completion of a contract with the Clarks for a thirty-inch object-glass, which, it is hoped, may be completed within two years if the glass disks can be procured from the makers of optical glass. The mounting of the telescope is to be made by the Repsolds at Hamburg. Having executed his mission, he sailed for his home on September 13, 1879.

EDITOR'S TABLE.

SOCIOLOGY AND THEOLOGY AT YALE COLLEGE.

SOME weeks ago an attempt was made to get up a public sensation out of a reported disagreement in the faculty of Yale College, concerning the teaching of sociology. It was alleged that a conflict had arisen between President Porter and Professor Sumner of the chair of Social Science, in regard to the use as a text-book of Spencer's "Study of Sociology"—a conflict in which the faculty participated, and which might lead to difficulty. Professor Sumner was interviewed, and said it was an old affair, and had been greatly exaggerated; and he hoped that the press would not disquiet itself by working up a discussion of the subject which could do no good to anybody. This was, of course, the signal of a general outbreak; both the secular and the religious journals "going in" with extraordinary unction. Though much interested in the matter, we acted upon the hint of Professor Sumner, and refrained from any remark in the May "Monthly." But the occasion has been used in such a way that some further comment is needful.

It was a wise and an appropriate thing on the part of the authorities of Yale College to establish a professorship for the teaching of social science. The subject is one of growing public importance in all civilized countries, and it is of transcendent interest in this country, where everybody takes so deep an interest in the administration of public affairs. The step was, moreover, imperatively demanded by the progress of knowledge. No intelligent man will deny that social order is based upon natural laws, and exemplifies cause and effect. Social phenomena may be analyzed and classified, and reduced to general expressions or principles, like the other phenomena of Nature. Notwithstanding the apparent chaos of politics, and the discords of legislation, there is nevertheless an underlying regularity in the action of social forces which makes rational politics and legislation possible. Laws are bad or good because there is a constitution of society by which their goodness or badness is determined. It is no longer a question that these social laws shall be worked out as an independent body of science; and this has been already so far accomplished as to lead to valuable practical results, and make it in the highest degree expedient that our eminent institutions of learning should recognize the subject, and enter upon the duty of teaching what is known of it, and of contributing to its further development.

In creating this chair, therefore, Yale College was only conforming to the intellectual requirements of the time; but it was nevertheless a courageous proceeding, for which the institution is to be honored. There is no mistaking the significance of the term *social science.* It implies that human society is a part of Nature to be studied by observation and induction, like the other parts of Nature, and to be pursued in conformity with established scientific method. That method is occupied with the determination of facts and those orderly relations of facts which are expressed as generalizations. As in astronomy or in botany so in sociology, the inquirer has to observe and compare phenomena throughout the whole field, so as to formulate the great activities that are displayed in each sphere, and thus arrive at a connected and comprehensive body of natural laws which make up the truths of the science. It is perfectly well known that the history of all the sciences shows that in their early stages one of the most formidable tasks of the investigator has been to get rid of the mass of irrational and superstitious beliefs by which the subjects have been overlaid and obscured. Social science is no exception, and in its present formative stage it presents precisely the same difficulties that other sciences have encountered, except that the errors and prejudices are here older, more inveterate, and deeply rooted than in any of the former spheres of scientific inquiry. In physics and chemistry the phenomena dealt with have been fully surrendered to the experimentalist and the reasoner, and there is no longer any interference with him in pushing his conclusions to the farthest limit. But sociology has not reached this fortunate stage. Its investigation is interfered with and impeded by theologians on religious grounds.

We are not at liberty to suppose that the intelligent authorities of Yale College were ignorant of what they were doing when they formally recognized that human society is to be studied in future by the method which has created all the other sciences, and made provision for its teaching in this manner. They knew that the first allegiance of the man of science is to truth as it is determined by processes of reason, and that he is bound to make no terms with preconceived erroneous opinions. That the trustees understood this and acted accordingly, is sufficiently shown by their selection of a professor to fill the new chair of Political Economy and Social Science. They could easily have chosen a facile man for perfunctory work, who would have occupied himself in expounding the miscellaneous matters that now pass current with the public under the name of "social science." But they sought and obtained a thoroughgoing student of the subject, a man of intellectual force and independence, who would give character to the position, and reflect honor upon the college, by his own original contributions to the science committed to his care. That among the considerable number of men who compose the governing body of Yale College—a majority of them clergymen, as we are told—there would have been some more narrow-minded than others, who would be disposed to interfere with the Professor's work and hamper his teaching, was perhaps inevitable; but the liberality and good faith of the institution were virtually pledged to maintain the rights of science in the liberty of its official representative.

Professor Sumner adopted as his text-book Spencer's "Study of Sociology," to be used by the senior class, consisting of young men from twenty to twenty-three years of age, of mature mind, and who have for years had the benefit of Yale College teaching. He adopted the book because it was the only one to be had at all suited to his purpose. It is an introduction to social science by its ablest living investigator. Profoundly impressed with the difficulties of the study in the present state of knowledge, with the misconceptions that are formed of it, and the causes of erroneous thinking in regard to it, Spencer deviated from his regular line of work to make this useful preparatory volume for those who propose to devote themselves to the general inquiry. He explained, in a succession of chapters, how men's judgments are liable to be warped in considering social questions by their habits of thought and their preconceived ideas. One of these chapters was entitled "The Theological Bias," and we are informed that this was considered by some of the faculty so objectionable as to render the volume unfit to be put into the hands of the Yale seniors.

Now, it is to be remembered that Yale College was committed, through the action of its authorities, to the honest teaching of social principles by the method of science. The object of the students was to gain true ideas of the nature and organization of human society. Nothing, surely, could be more pertinent, or necessary, than for them to be put upon their guard against sources of error in considering the subject. If there is a bias from theological influences that is calculated to vitiate or pervert the judgment upon social questions, what could be more important than that it should be pointed out? In dealing with society from a scientific point of view, Mr. Spencer had to consider it in its widest relations, or as manifested in varying grades, by all races of men upon the earth. In all forms of society religious systems play a leading part, but these systems are diverse and numberless. Mr. Spencer, therefore, drew his illustrations of the distorting influence of theological beliefs upon views of society from different quarters. Mohammedans and Feejeeans, Catholic and Protestant Christians, are cited to exemplify the common tendencies of theological doctrine to obscure the mental vision and prejudice opinion. He shows, moreover, with equal force, how the anti-theological bias may produce, and has produced, the same perverting effects.

The difference in the points of view of the theologian and the scientist comes out here sharply. Science inquires into the laws of phenomena; social science into the laws of social phenomena. As societies have developed, religious systems have also grown up as a part of the general phenomena of social growth. Social science is concerned with religion as a universal fact of human nature, which gives rise to universal social effects—it deals, in short, with the natural laws of universal religious phenomena. With these views theology has no sympathy. It is scornfully and passionately rejected by the religious devotee. His position is that there is one religion that is absolutely true, and that all other religions are absolutely false, and any notion of treating them all alike is rejected with horror. And the one religion that is true, being a supernatural system, is not to be studied as a natural phenomenon, or by the method of science. The devout mind thus recoils at the very fundamental conception of social science, which it regards as the offspring of infidelity and atheism.

To this source of prejudice Mr. Spencer devoted a chapter in his book, and how necessary it was is now abundantly apparent. The religious press has raised a storm of denunciation against the sociologist and all his books, and the professor, faculty, and college that have had anything to do with them. Religious prejudices are stimulated to their utmost by the *odium theologicum*. The "Study of Sociology" is cursed as a book of atheism, and the school that uses it is condemned as a propagator of infidelity. That stanch exponent of the spirit of orthodoxy, the "New York Observer," makes up a sharp issue between Christianity and social science as follows: "The traditions of the college (Yale) are all in favor of the Christian religion, and the public may be assured that the faculty and trustees will never consent to have the atheism of Spencer offered to the students. They can find enough of that without going to college to find books in which Christianity is argued against and ridiculed. We are glad that President Porter stands firm, and we may also add that the resignation of any professor who has sympathies with Herbert Spencer will be a great advantage to the college."

The "Christian Intelligencer" says: "Herbert Spencer's 'Sociology' has been introduced as a text-book. The faculty are divided in regard to the use of such a work. The President, it is said, opposes the study of a book essentially infidel. There should be no difference, no discussion among honest men upon such a matter. Yale College has been endowed by the gifts of Christian men almost exclusively. To use the foundation they have established for the propagation of skepticism is a breach of trust and is no better than burglary or forgery."

The "Christian at Work" remarks: "It might be of little moment if his text-book were a treatise on pure mathematics or chemistry. But it is otherwise upon such a subject as sociology. That concerns the relation of man to the state, and *vice versa;* it treats of the moralities, and of laws designed to conserve the Sabbath and enforce morality, and of the claims of religion. To all such laws Mr. Spencer is avowedly hostile. . . . Put the youth under the dominion of Spencer's social system, and they will deny the right of the state to enforce a day of rest, or make laws for any other purpose than the bare protection of life and property. Under Spencer's system all other laws would be done away with, and we should have a condition of affairs in which one right alone would be recognized—the right of every one to do as one pleased. . . . We trust the accomplished Professor will himself see the wisdom of deferring to a very proper feeling which we believe unmistakably exists on the part of the Christian public, that nothing should be allowed, however otherwise excellent in itself, which will in the slightest degree unsettle the minds of the young by giving them a bias toward a pernicious, dangerous sociology, which seeks to eliminate public education from the state, and rejects the moral element in legislation save as required for the protection of life and property."

The "Independent" says of the "Study of Sociology": "Theologically it is probably the most objectionable book Spencer has written, making no secret of its contempt for believers in the Christian religion, who are told that they must lay aside their faith if they wish to study sociology. There is enough of this intolerance to make the book decidedly offensive. We are not surprised that complaint was made against the book, although we believe that no pupil of Professor Sumner will accuse him of any lack of faithfulness in pointing out the weak or misleading passages in any author whose text-book he uses. We presume that, before another class has occasion to pursue the study, the works to which this was an introduction, or some better book, will be ready for use, and will replace, with its collections of facts, the offensive philosophizings of the 'Study of Sociology.'"

These extracts are fairly representative of the ideas and the spirit of the religious press of this country. Passing by the various misrepresentations with which they bristle, what is their common upshot? That in its treatment of social science Yale College is bound to take into account, first of all, its theological character as a Christian institution. We say, on the contrary, that the first duty of Yale College, as a seat of liberal learning, is to truth, which is to be cordially welcomed from all sources. It is bound to recognize, first of all, that knowledge is progressive, and to teach it in its most developed and perfected forms. It is not at liberty to disregard the lessons of experience. There was a time when the great universities of Europe were called upon to resist the progress of astronomy, in the name of Christianity. Later, they were again called upon to resist the progress of geology, in the name of Christianity. And now our colleges are called upon to resist the progress of sociology, in the name of Christianity. The demand, futile in the former cases, is now ridiculous. It is an anachronism, and serves only as a register of the survival of bigotry. The mortifying fact is, that we in this country are behind the age in liberty of thought as a guiding principle in higher education. The Reverend Chancellor of the University of New York is reported to have declared that, if the works of Herbert Spencer should be introduced into the institution over which he presides, he would resign his position. Yet these works are introduced and freely used in the English universities. Alike in England, Scotland, and Ireland, students are required to be acquainted with the contents of the "Psychology"; and in some of the universities Spencer's philosophical treatises are used as text-books. Oxford led the way a dozen years ago with the "Biology" as well as the "Psychology," and even went so far as to allow Spencer's works to be given as prizes. In France, the state authorities, who superintend educational affairs, have formally adopted Spencer's works to be introduced into the libraries of the lyceums and colleges throughout the country, and have also made them available for prizes. And all this without any such foolish noise and fanatic splutter as has followed a similar attempt in one of our own colleges.

Something has, however, happened in France equally funny and instructive, which it is proper to mention, especially as it may serve as a hint for compromise on this side. The question is, When an author can not be answered, what is to be done? The tactics of the Chancellor above referred to is to run; but there remains the alternative of expurgation. If there are things that can not be replied to, and which will "pervert the young mind," cut them out. Now, the French have very little trouble with Spencer's treatment of religious subjects, but his irreverence for the ancient classics greatly troubles them. It might be thought a good method to point out his errors to students, but that plan does not meet with favor. And so the Minister of Public Instruction in France has arranged to prepare an edition of Spencer's "Education" which the Government may approve, and in which the part dealing with science and classics is omitted.

Now, why not have an edition of "The Study of Sociology" with the part on the "theological bias" left out? The "Independent" is confidently looking for a new text-book which Professor Sumner can use without theological objection; but why not adopt the French dodge, and protect the students as effectually as may be by dropping out of the existing volume all reference to the influence of religious prejudices in hindering the scientific investigation of social phenomena?

MISUSE OF THE "SCIENCE PRIMERS."

To the excellence of the well-known series of "Science Primers," of which there are now a dozen, we have uniformly testified. They are written by the ablest scientific men of England, who are masters of the topics upon which they write, and they have been prepared under the eminent editorial supervision of Professors Huxley, Roscoe, and Stewart. They have made a very favorable impression upon the public, and met with a success that was sufficiently assured at the outset. A million of the books, it is said, have been called for in England, and they have had a large sale in this country. Professor Huxley engaged to write an introductory primer to the series, which has just appeared, and the public is informed that sixteen thousand copies of it were ordered in advance, of the London publisher. Authors and booksellers are to be alike congratulated upon so brilliant a result.

The secret of this success is undoubtedly to be found in the perfect adaptation of the books to the existing conditions of education. They may be employed in schools without giving the slightest trouble, and are certain to be favorites with teachers who can use them with a minimum of intellectual exertion. They are all so plainly written that there is no mistaking the writer's meaning; there are no perplexing problems to be solved; the pupils can learn the short lessons with ease, and the recitations should go on with the utmost smoothness and facility. Yet this perfect conformity of the books to old established school habits, while it has secured their immense success, raises serious questions as to their adaptation to the improved methods of study which are now demanded in early scientific education.

From this point of view we think the title of the series misleading, and that as a consequence the books are liable to be put to a wrong use. The term *primer* suggests the lowest grade of elementary school-books—first books for primary classes, or for children beginning to study. The "Science Primers" are obviously unsuited for this purpose. We should say that the distinguished gentlemen who prepared them, and who are all of them occupied in the absorbing work of scientific research in their respective departments, have not given due attention to that very important matter in early education—the minds of children. This is, in fact, a science by itself of great interest and no little complication, and for the most part quite alien to the special pursuits of these authors. A man may be deep in physics and profound in astronomy, and yet know very little of the mechanism, growth, and various conditions of the unfolding faculties of the child. It matters nothing how clear, simple, and accurate is the text of a primer if it is not skillfully suited to the early stages of mental activity; and this is where the "Science Primers" fail as books for beginners.

It is clear that children can not at first grasp generalizations; and to begin by giving them general principles, and making them learn lessons embodying the results and outcome of scientific thought, is a fundamental educational mistake. They should begin with the simple, the concrete, the familiar, and be very gradually and very slowly led on to combinations of ideas and the perception of simple relations; and only in the higher stages of mental growth should they be tasked with those highest products of science—system, exactness, and abstraction. Knowledge may be put into a child's mind wrong-end foremost, so to speak, and so as to disturb and paralyze its faculties, rather than to favor their natural and healthy growth. The first step in the scientific education of children ought not to be an abrupt transition from their intercourse with the natural objects around them to lesson-learning from books; it should be simply to direct and guide them in making observations. The process should be continuous with their unguided and spontaneous activities, and stimulated by the cultivation of curiosity. Play may run into simple experiments under such careful management as not to create weariness or distaste for this kind of effort.

The "Science Primers" do not sufficiently conform to this method to make them suitable books for beginners. They in fact belong to the advanced, if not the adult, stage of mental development. In the first two books that were published, the "Primer of Physics" and the "Primer of Chemistry," there is a common preface, in which it is said that "the object of the authors has been to state the fundamental principles of their respective sciences in a manner suited to the pupils of an early age. They feel that the thing to be aimed at is not so much to give information as to endeavor to discipline the mind in a way that has not hitherto been customary, by bringing it into immediate contact with Nature herself. For this purpose a series of simple experiments has been devised, leading up to the chief truths of each science. These experiments must be performed by the teacher in regular order before the class." This is all that is said regarding the adoption and educational use of these books, and it is open to grave criticism.

In the first place, the *fundamental principles* of the sciences are not "suited to pupils of an early age," and can not be made so by any manner of presentation. The immature mind can not apprehend them, and, though the language in which they are embodied may be learned by heart, there will be no real understanding of the truths conveyed, and the sole "discipline" that can be gained will be that of loading the memory with undigested and unassimilated statements. The mature mind of the race has been long and painfully occupied in working its way to the "fundamental principles" of science; and to pour these into the minds of "pupils of an early age" is not a wise or enlightened practice. Undoubtedly the true method is to bring the young mind "into immediate contact with Nature herself"; or rather to *keep* it there, as this is where the educator at first finds it. But what is "immediate contact with Nature" in this case, but for the pupil to occupy himself with the objects of Nature—to make his own observations, to make his own experiments, to start his own questions, solve his own difficulties, and do his own thinking? All this would be at first rudimentary and crude, and the pupil will not get at "fundamental principles," but he will cultivate his faculties in the only way they can be properly cultivated, by self-exertion. The Science Primers fail for beginners by making no provision for this kind of activity. They are to be told in the old way—they are to have things shown, and explained, and made clear, and everything done for them. "The experiments must be performed by the teacher in regular order before the class." This is the ancient college way of imparting instruction; but even the colleges are departing from it as an intellectual failure, and are establishing physical and chemical laboratories in which the students can be really brought "into immediate contact with Nature herself." Listening to lectures, witnessing experiments, and reciting from text-books, is not that "immediate contact with Nature herself" which rational education now demands. And what is true of the Primers of Chemistry and Physics in this series is equally true of the Primers of Geology, Botany, Astronomy, Logic, and Political Economy. They are all lesson-books of fundamental principles, clear and admirable as expositions, but all of them as much second-hand book-knowledge as the "Primers of History."

It was hoped that Professor Huxley, as chief editor of this series, and writer of the Introduction to it, would have taken up the question of primary scientific education, at least sufficiently to explain and limit the school use of these little books. But he considers other questions, as we show elsewhere in the notice of his volume; and this is the more disappointing, as Professor Huxley has ever been a strenuous advocate of direct first-hand knowledge in science. He long ago declared that "mere book-knowledge in physical science is a sham and a delusion"; and in his last admirable work on the "Study of Zoölogy" he enjoins that the book be read "crayfish in hand"; but is not this principle of equal if not greater importance when it is proposed to deal with "pupils of an early age"?

There is one book, however, introduced into the American edition of the series, which is not liable to the objections here indicated. This is the "Inventional Geometry" of Mr. W. G. Spencer. It is not a child's book, but it adopts the right method. It may be taken up by boys and girls twelve or fifteen years old, and it will do more to cultivate and strengthen their original powers of thought, more to give them clear ideas and mental self-reliance, than all the other Primers of the series put together. But, as it implies some mental effort to gain the power that can only come from exercise, it is not so *easy* as the other books, and will, therefore, not be a favorite with teachers in schools, and can hardly be expected to have the remarkable success of the other Primers.

LITERARY NOTICES.

Chemical Exercises in Qualitative Analysis. For Ordinary Schools. By George W. Rains, M. D., Professor of Chemistry in the University of Georgia. New York: D. Appleton & Co. Pp. 59. Price, 50 cents.

Under this modest title, and within very moderate limits, Professor Rains has made a very considerable contribution to sound scientific education. He has had much experience in introducing boys into chemistry, and the course of exercises here worked out he has long verified in practice. His object is to bring the minds of pupils into immediate contact with Nature, and so he puts them at work, at the outset, to find out by trial the chemical properties of substances. His little book provides for no recitations, but for elementary chemical work. The learner is not told; he finds out the properties and reactions of bodies by testing them and by experiment. His progress consists in solving problems, and making what are to him a course of new discoveries. The book is based upon the idea that mere book-knowledge in chemistry is a sham and an imposture.

To facilitate the mode of study adopted, Professor Rains has devised an ingenious and most convenient portable laboratory, to which his manual is adapted, and which will be a great help to students, whether working alone or in school-classes under a teacher. We will give a drawing next month of this useful contrivance, and describe Professor Rains's method more fully.

Henry's Contribution to the Electro-Magnetic Telegraph. With an Account of the Origin and Development of Professor Morse's Invention. By William B. Taylor. Reprinted from the Smithsonian Report for 1878. Washington: Government Printing-Office. 1879.

The name of Professor Henry is not among those who are associated in the popular mind with the electric telegraph, and yet without his discoveries the electro-magnetic telegraph of to-day could not exist. Though, in making his electric investigations, he was not working with the aim to construct a telegraph, he yet clearly perceived the bearing of his results upon such a system of communication. The telegraph has been a growth to which many minds contributed, and it is desirable that the labors of each of the contributors should be placed in such relations as to show their comparative value. This Professor Taylor has done in the above pamphlet, in which the remarkable investigations of Professor Henry receive a recognition that their importance deserves. Professor Taylor reviews the attempts to operate a telegraph by frictional electricity, then by galvanism, by galvano-magnetism, and finally by means of the electro-magnet. Professor Taylor thus states the contribution of Professor Henry to the solution of the problem: He has, he says, "the preëminent claim to popular gratitude of having first practically worked out the differing functions of two entirely different kinds of electro-magnet: the one surrounded with numerous coils of no great length, designated by him the 'quantity' magnet, the other surrounded with a continuous coil of very great length, designated by him the 'intensity' magnet. The former and more powerful system, least affected by an 'intensity' battery of many pairs, was shown to be most responsive to a single galvanic element: the latter and feebler system, least influenced by a single pair, was shown to be most excited by a battery of numerous elements; but at the same time was shown to have the singular capability (never before suspected nor imagined) of subtile excitation from a distant source. Here for the first time is experimentally established the important principle that there must be a proportion between the aggregate internal resistance of the battery and the whole external resistance of the conjunctive wire or conducting circuit; with the very important practical consequence that, by combining with an 'intensity' magnet of a single extended fine coil an 'intensity' battery of many small pairs, its electro-motive force enables a very long conductor to be employed without sensible diminution of the effect." These investigations of Henry were made from 1829 to 1831. They made the magnetic telegraph, which the English physicist, Barlow, noticing the rapid diminution in the intensity of the current, had some years before declared impracticable, possible. All later inventors and investigators in telegraphy have had to build upon these investigations. Professor Taylor, in reviewing the work of Morse, points out that he was greatly delayed in his work and committed many errors from ignorance of the existing state of electrical knowledge, and especially because of his ignorance of the labors of Professor Henry. He further points out that the work for which Morse gets credit is, in all its more important features, the work of another man—Alfred Vail, who, with Dr. Gale, was associated with Morse in perfecting the invention. Professor Taylor states that the Morse alphabet and the instrument that was found in practice to work it were both the sole invention of Mr. Vail. The pamphlet will be found an interesting review of this important invention, containing much hitherto unpublished, and giving such recognition of the labors of those contributing to it as their importance deserves. Professor Taylor was for many years connected with the Patent Office, and has therefore had excellent opportunities of informing himself on the subject.

History of Political Economy in Europe. By Jérôme-Adolphe Blanqui. Translated from the fourth French edition, by Emily J. Leonard. With a Preface by David A. Wells. New York: G. P. Putnam's Sons. 1880. Pp. 562. Price, $3.50.

This is the first appearance in English of the celebrated work of the French economist Blanqui. It is somewhat remarkable that a translation has not before been made, as there is no English work covering the same ground, and as M. Blanqui has succeeded in putting in a moderate compass a large amount of information concerning economic theory and practice, and putting it, moreover, in a way that will prove very attractive to the general reader. Though it is more than forty years since the book was first published, it has lost little or none of its interest for the present, and its translator has conferred a favor upon the public by her excellent rendering of the original. M. Blanqui was the pupil of J. B. Say, and, on the death of that economist in 1833, he succeeded him in the professorship of Political Economy in the Conservatory of Arts and Trades. In his discussion of social and economic questions, the humanitarian element is predominant, and the great value of political economy to him was that it consisted of a body of most beneficent truths which held out the promise and pointed the way to an increasing betterment of the condition of all classes. He had, therefore, a warm interest in all questions concerning the improvement of the industrial classes, and regarded with sympathy the various schemes, rife in his time, for furthering their welfare. With great admiration for the school of English economists, and according to them the honor of placing the science upon a true foundation, he yet protested that their formulas were too rigid, and that they had not taken account of the grain of truth that, along with many vagaries, was to be found in the doctrines of various social sects.

In his view, political economy did not begin when men first carefully studied the phenomena of wealth, and endeavored to elaborate a body of doctrine, but it began much earlier. Men became political economists when they began to exchange the products of their labor, and when they commenced to exercise foresight in providing for their material needs. Since then economic phenomena, as well as the theories held concerning them, have slowly advanced—the one in complexity and variety, the other in a more perfect comprehension of the relations of the facts. M. Blanqui therefore begins his work with a consideration of the political economy of the Greeks and Romans, and traces it onward through the middle ages to the time at which he wrote. In this survey he notices the importance attached by the Greeks to financial matters, the contempt of the Romans for labor and commerce, the influence of Christianity, which he says changed the basis of civilization from slavery to freedom, the change impressed on European life by the influx of barbarians, the rise of the feudal system, and the influence of the Crusades in giving an impetus to commerce. In considering the rise of credit and the institution of banks, he points out the value of the services of the Jews, to whom finance owes so much.

Modern commerce properly begins with the rise of the Italian commercial cities, and thence onward it moves steadily if slowly. Its theory is the mercantile system. Nations only grow rich by despoiling each other, and money is alone riches. This theory, once universal, has not even yet disappeared. It has survived the clearest demonstrations of its falsity, and influences to-day much of the speculation and legislation upon economical matters. The first important school to combat it, and to lead the way to a true theory of wealth, was that of the *Economists*, which arose in France just after the disastrous failure of Law's scheme. Quesnay was one of its founders and most distinguished representatives. It found prepared for it a soil in which it readily took root and flourished. Law's failure had produced an entire revulsion in French sentiment. "People," says M. Blanqui, "had for some time deemed money to be wealth in an especial sense; . . . there were henceforth no true riches but land." The *Economists* came preaching this doctrine. To them agriculture was the only productive occupation. "Manufacturers, traders, workmen, were all paid clerks of agriculture, which was the sovereign creator and dispenser of all wealth." Landed proprietors were rightly preëminent over all other classes. They reaped all wealth; they should, therefore, pay all taxes. Hence the *Economists* would have but one tax—that upon land. And the same reasoning led them to entire freedom of trade. Able men rallied to the support of the new views, and there gradually grew up a body of statesmen imbued with them, one of whom, Turgot, was to attempt to carry their formulas into practice.

The *Economists* were mistaken. They failed to see that wealth can be created by labor; they were blinded by their doctrine of the importance of land, but they have rendered great service. "Their books are forgotten; but their doctrines have germinated like a good seed, and the precepts which they taught have made the circuit of the world, freed the industrial arts, restored agriculture, and prepared the way for commercial liberty." It was reserved for Adam Smith to see clearly what the *Economists* saw dimly, to correct their errors by a true analysis of the phenomena of wealth, and to place economics on an enduring foundation. He restored to labor the position of a creator of wealth denied it by the *Economists*, and he first pointed out clearly the results of the division of labor. He placed commercial liberty upon an impregnable basis, and showed how private interest freed from restrictions works for the best welfare of the individual and society. Great as was his genius, "Adam Smith did not, however, have the honor of creating political economy at a single stroke"; but he laid the foundation upon which his successors securely built. The *Economists* had given to land too prominent a place; he gave it to labor. This his followers corrected: they adjusted the parts, recognized the place of capital, and developed the science symmetrically. But they all failed to recognize sufficiently the welfare of the worker. They all regarded him too exclusively in the light of an economic machine for the production of wealth. This error the economists of the French school have corrected. They have insisted that the value of increase of wealth is to be unceasingly judged by what it brings to the workers, and they withhold their admiration if the thing it brings be not good: "We are to-day obliged to seek a regulator, and to put a curb on those gigantic instruments of production which feed and which starve men, which clothe and which despoil them, which relieve and which crush them. The question is no longer, as in the time of Smith, exclusively that of accelerating production: the latter must henceforth be governed and restricted within wise limits. The question is no longer of absolute wealth, but of relative wealth; humanity demands that masses of men who will not profit thereby be no longer sacrificed to the progress of public opulence. Thus decree the eternal laws of justice and morality, too long disregarded in the social distribution of the profits and the labors; and we will no longer consent to give the name of wealth save to the sum of the national product equitably distributed between all the producers. Such is the French school of political economy to which we profess to belong, and its ideas will make the circuit of the world."

The above will, perhaps, give some idea of the general spirit and drift of M. Blanqui's work in viewing social questions, but no one at all interested in such questions will fail to read one of the most fascinating economic works ever published.

A Practical Treatise on Nervous Exhaustion; its Symptoms, Nature, Sequences, Treatment. By George M. Beard, A. M., M. D. New York: William Wood & Co. Pp. 198.

Dr. Beard's work deals not only with a very important subject to which he has paid long professional attention, but to a subject of prominent and painful interest in this country. Nervous exhaustion, or, as he names it, *Neurasthenia*, he declares to be at once the most frequent, the most interesting, and most neglected disease of modern times; while the family of disorders that have been hitherto grouped together under the name of "general debility," "nervous prostration," "nervous debility," "spinal weakness," "spinal irritation," etc., are of comparatively recent development and abound especially in the Northern and Eastern parts of the United States. The author thus states his purpose in the preparation of the book: "To describe with thoroughness if not exhaustively the symptoms of neurasthenia—those hitherto assigned to the other affections or regarded as special and distinct diseases themselves; to show their relation and interdependence; to distinguish them from the oftentimes closely resembling symptoms of organic disease on the one hand, and the symptoms of hysteria and hypochondria on the other hand; to unify and harmonize the complex developments and manifestations of this malady; to indicate its pathology and *rationale*, and trace out in detail its prognosis, sequences, treatment, and hygiene—this is the task I have undertaken in the present volume."

Dr. Beard affirms that there has been a very important progress in the treatment of these affections during the last ten years. "In no department of therapeutics has there been even in this most active age so rapid and successful advance as in the management of nervous exhaustion, and the diseases that result from and are related to it; and hence a subject, the interest of which was originally scientific and philosophic, is now of direct practical and personal concern not only to specialists in the diseases of the nervous system, but to practitioners and to sufferers everywhere."

As the work is chiefly practical and designed for the use of the medical profession in treating the disease as it is found, the question of the causes which lead to it is not taken up. This is a very important branch of the subject, which requires to be itself separately and fully dealt with. Dr. Beard accordingly has in preparation and nearly completed a work on American nervousness, intended to be supplementary to the present treatise, which will discuss both the causes and the consequences of the rise and increase of neurasthenia, and the general nerve sensitiveness which is a kindred phenomenon in this artificial and excitable age. The author remarks that a philosophic and thorough analysis of American nervousness must be a contribution to sociology involving many problems of race, climate, institutions, and social customs.

Science Primers: Introductory. By Professor T. H. Huxley. New York: D. Appleton & Co. 1880. Pp. 94. Price, 45 cents.

The appearance of this little volume has been waited for with eager interest and much impatience, owing to the popularity of the science series, to which it is a stepping-stone, and to the celebrity of its author. Much was expected, and the general expectations will not be disappointed. In the happy selection of its subjects, in the felicity of its illustrations, in the admirable clearness and simplicity of its style, and in the instructiveness of the lessons it inculcates, Professor Huxley's Primer is quite unrivaled, and it will be read by thousands with equal pleasure and advantage. It aims to convey a general idea of the nature and importance of scientific knowledge, to explain science as a method of thinking, to show its practical uses, and to exemplify its systematic bearings and various aspects by means of the most familiar objects. The first division of twenty pages, under the head of "Nature and Science," treats of Causes and Effects, the Properties and Powers of Bodies, what is meant by the Order of Nature and the Laws of Nature, and how scientific knowledge is obtained. The second division is devoted to "Material Objects," and sixty pages are given to Mineral Bodies. Water is chosen as a representative natural object, and its remarkable properties are explained step by step, so as to bring out the fundamental physical principles involved in the three states of matter. Ten pages are then given to the properties of Living Bodies, and the Primer closes with a few observations on immaterial objects.

We refer elsewhere to the series of works to which this book belongs, with a view of guarding against their misemployment in schools.

Health and Health Resorts. By John Wilson, M. D. Philadelphia: Porter & Coates.

Dr. Wilson is of the opinion that many erroneous notions prevail among the Americans as to the value of health resorts, especially those of foreign countries, and he has therefore in this work undertaken to state the value of such places and the conditions that must be fulfilled as to diet, treatment, etc., in order to obtain their benefits. After a short consideration of health and disease, he considers the general principles of regimen for invalids at health-stations, and the therapeutical action of mineral waters, their use and abuse, and the value of baths. He also considers the best winter-stations for consumptives and a number of the foreign mineral springs. Dr. Wilson insists that it is not necessary to go away from this country to get all the advantages of foreign springs, as there is scarcely one of these that has not its counterpart in this country.

Memorandum in regard to Instruction in the Mechanic Arts. By Edward Atkinson. Prepared at the Request of the Committee on Prisons of the Massachusetts Legislature.

In this memorandum Mr. Atkinson urges the adoption of such a course of instruction with actual practice in workshops, in the reformatory institutions of the State, as has been carried on for some years in the Massachusetts Institute of Technology. The success of this system has been so gratifying at this institute that Mr. Atkinson believes it can not but be of great value in prisons and reformatories. He submits a plan of a workshop to accommodate four hundred pupils, and arranged to give instruction in carpentry, blacksmithing, foundry-work, vise-work, brazing, wood- and metal-working and finishing. The only objection Mr. Atkinson finds to his plan is in the fact that graduates of such reformatories will be much better qualified to earn a living than most of the graduates of the common, and some of the graduates of the higher, institutions of learning.

The Cotton-Worm. By Charles V. Riley, M. A., Ph. D. Washington: Government Printing-Office. 1880.

This is the third bulletin issued by the United States Entomological Commission, and is devoted to a summary of the natural history of the cotton-worm, with an account of its enemies and the best means of controlling it. Illustrations are given of the worm and its enemies, as well as of the various machines designed to be used in exterminating it. Much valuable information will be found in it of service to the planter, both as to the peculiarities of the worm, and on the best means of protection. The bulletin is sent to those desiring it, upon application to Washington.

A Subject-Index to the Publications of the United States Naval Observatory from 1845 to 1875. By Edward S. Holden. Washington: Government Printing-Office. 1879.

Professor Holden states that the twenty-two volumes issued from this observatory from 1845 to 1875 contain, on the average, five hundred pages each of valuable observations and discussions, which it is desirable should be easily accessible. He has, therefore, undertaken this very excellent index. It is in the form of a quarto, of seventy-two pages, in paper binding.

Report on the Lands of the Arid Regions of the United States. With Maps. By J. W. Powell. Second edition. Washington: Government Printing-Office. 1879.

In the first three chapters of this volume Major Powell treats of the physical characteristics of the arid regions of the United States, and the rainfall of the Western portions of the country. Mr. G. R. Gilbert has four chapters on the water-supply, on irrigable lands, and on the physical features of the lands of Utah. There is also a paper by Captain C. E. Dutton on the irrigable lands of the valley of the Frazer River; and one by Professor A. H. Thompson on the irrigable lands of that portion of Utah drained by the Colorado River and its tributaries. The concluding chapter of the volume, by Willis Drummond, Jr., discusses the question of land grants as aids to internal improvement. The interest and value of the report are shown by the fact that the first edition was soon exhausted, and a second one called for.

Studies in Fermentation; the Diseases of Beer; their Causes and the Means of preventing Them. By L. Pasteur, Member of the Institute of France, the Royal Society of London, etc. Translated by Frank Faulkner and D. Constable Robbe. Macmillan & Co. Pp. 418. Price, $6.50.

There are but few subjects that would seem less attractive than the scientific investigation of ferments and the processes of fermentation, yet the book before us is alive with interest from beginning to end. This is due to the genius of the author, the scientific importance of his inquiry, the spirited controversies which have recently grown out of the inquiry, and its important practical results. Pasteur is a man remarkably endowed for subtile research. His investigation of the diseases of the silkworm was one of the most difficult, refined, and successful of modern researches. A delicate experimenter, a sharp observer, and a man of keen insight and careful judgment, he has taken the acknowledged lead in investigating the obscure phenomena of microscopic life at the present time. The questions opened are the deepest in modern thought, involving nothing less than the origin of life-forms, and the method of Nature regarding vital phenomena. Pasteur has been in the center of the battle of spontaneous generation, and yet so practical have been his investigations that the brewers are of all men most interested in them. The present work deals with the diseases of beer, and those deteriorations of its processes that are involved in the changes of fermentation; and its leading translator is an author of the "Art of Brewing." The work will be of great interest, therefore, to all engaged in this branch of manufacturing industry, not only by throwing light upon the theory of brewing, but by the solutions it gives of serious practical difficulties hitherto encountered in the brewer's art. Pasteur's elucidations of fermentative action bear also upon the operations of wine-making and vinegar-making, as well as beer-making.

A Text-Book of Physiology. By M. Foster, M. A., M. D., F. R. S., Prælector in Physiology and Fellow of Trinity College, Cambridge. With Illustrations. Macmillan & Co. Pp. 720. Price, $3.50.

The writing of his "Physiology" by Dr. Foster was far from being a case of book-making in the ordinary sense. He is a man not only devoted to his subject, but especially and assiduously devoted to its progress, so that the preparation of his text-book was but an incident in his studies, and has, moreover, been a continuous work with him for several years. The third edition, revised and enlarged, is now issued; and it represents, perhaps, better than any other book the recent advance and present condition of physiological science. Dr. Foster is at the head of the new physiological laboratory at Cambridge, England, where the experimental method of physiological inquiry is vigorously pursued; and his text-book is, of course, prepared from that point of view. Under this method, physiological science is slowly acquiring certainty and increasing precision in its conclusions, as no one can fail to see who compares Dr. Foster's text-book with the standard treatises of a few years ago. We agree with Professor Burt Wilder that this is "in some respects the best physiology in the English language." We note that a cheap students' edition of the work is to be issued in a short time.

A Forbidden Land; Voyages to the Corea. By Ernest Oppert. With 21 Illustrations and Two Charts. New York: G. P. Putnam's Sons. 1880. Pp. 334. Price, $3.

This is an interesting account of a little known country in Eastern Asia. The present kingdom of Corea consists of a large peninsula east of the Chinese Empire, extending from 42° north latitude to the

Straits of Corea. The country has always been exclusive in its policy, this exclusion extending in later years even to its near neighbors, China and Japan, so that very little has been known of the physical features of the country or of the habits and character of its people. The country for centuries has been at war with China and Japan, and the scene of fierce internal feuds, and only latterly has it been able to secure itself against its foreign enemies and unite into one kingdom under one ruler. It has been supposed that the Corean Peninsula was settled from China, but this, Mr. Oppert declares, is an utter mistake. The Coreans differ widely in their customs from the Chinese, and do not present the physical appearance to justify such an origin. The upper classes of the Coreans are of a Caucasian type and the lower of a Mongolian one. The country is destitute of native histories, and the people profess to know nothing of their origin, though some of the aristocratic classes have fabulous accounts of it. The author gives much interesting matter concerning the customs, institutions, and natural features of the country, and feels impatient at its seclusion from the trade of the world, and appears to think a forcible opening of it desirable.

United States Geological and Geographical Survey of Colorado and Adjacent Territories in 1876. By F. V. Hayden. Washington: Government Printing-Office. 1878.

This is the tenth annual report of the survey under the direction of Professor Hayden, and is devoted to the survey completing the work in Colorado and portions of adjacent Territories. The report consists of an account of the work done in the geology, topography, archæology and ethnology, and paleontology and zoölogy of the region. The report has a number of excellent maps, and numerous lithographic plates of the ancient mines examined, and of specimens of the pottery, both ancient and modern, of the natives of the region.

Sunshine and Storm in the East. By Mrs. Brassey. New York: Henry Holt & Co. 1880. Pp. 438. Price, $3.50.

Those who enjoyed Mrs. Brassey's account of her "Voyage in the Sunbeam" will welcome her present account of her two visits to Cyprus and Constantinople. The book is in the form of a diary, which is not, it seems to us, a very interesting way of presenting the scenes and incidents of travel. The work is profusely illustrated and handsomely printed on heavy calendered paper. The cover strikes us as somewhat flashy, but is designed, we presume to be artistic.

PUBLICATIONS RECEIVED.

Does Spiritualism transcend Natural Law? By W. G. Stevenson, M. D. 1880. Pp. 25.

Interoceanic Ship-Railway. Remarks of Dr. William F. Channing before Select Committee of the House of Representatives, March 27, 1880. With Exhibits. Pp. 10.

The Education of the Blind. An Address before the Wisconsin Teachers' Association, July 10, 1879. By Mrs. Sarah F. C. Little. Pp. 15.

A Catalogue of the Birds of Indiana, with Keys and Descriptions of the Groups of Greatest Interest to the Horticulturist. By Alembert W. Brayton, B. S., M. D. Indianapolis: Douglass & Carlow. 1880. Pp. 77.

Remarks of Hon. Barton A. Hepburn in Support of the Bill entitled "An Act to regulate the Transportation of Freight by Railroad Corporations." Albany: Weed, Parsons & Co. 1880. Pp. 30.

A Study of some of the Starches. By Mrs. Lou Reed Stowell. Ann Arbor. 1880. Pp. 17.

College Libraries as Aids to Instruction. Circulars of Information of the Bureau of Education. No. 1. 1880. Washington: Government Printing-Office. Pp. 27.

The Unity Pulpit. Boston. Sermons of M. J. Savage. No. 21. "The Struggle and Triumph of Man." No. 22, "Patience." No. 23, "The Nearness of God." No. 24, "Faithfulness." By W. H. Savage. No. 25, Series of Talks about Jesus: I. "Sources of our Knowledge." No. 26. "Channing Unitarianism." No. 27, Talks about Jesus: II. "The Miraculous." No. 28, Talks about Jesus: III. "Birth and Childhood."

On the Removal of Foreign Bodies from the Ear: With Four Cases. By Charles Stedman Bull, M. D. New York. 1880. Pp. 9.

Revised Catalogue of the Birds of Chemung County, New York. By W. H. Gregg, M. D. Elmira. 1880. Pp. 25.

Report of the Director of the Central Park Menagerie. New York: M. B. Brown, Printer. 1880. Pp. 32.

Railway Land Grants of the United States. By E. H. Talbot. Chicago: The Railway Age Publishing Company. 1880. Pp. 66.

Valedictory Address to the Graduating Class of the Woman's Medical College of Pennsylvania. By Frances Emily White, M. D. Philadelphia: Grant, Faires & Rodgers, Printers. 1880. Pp. 16.

The Tongue of the Honey-Bee. By Professor A. J. Cook. Reprint from "The American Naturalist." Illustrated. Pp. 9.

On the Foramina perforating the Posterior Part of the Squamosal Bone of the Mammalia. By E. D. Cope. Pp. 10.

A Review of the Modern Doctrine of Evolution. By E. D. Cope. Reprint from "The American Naturalist." Illustrated. Pp. 21.

Some Thoughts and Facts concerning the

Food of Man. By Dr. E. L. Sturtevant. From the "Report of the Secretary of Connecticut Board of Agriculture." 1880. Pp. 41.

Muscle-Beating for Healthy and Unhealthy People. By M. Klemm. Illustrated. New York: M. L. Holbrook & Co. 1879. Pp. 56. 30 cents.

The Problems of Insanity. A Paper read before the New York Medico-Legal Society, March 3, 1880. By George M. Beard, M. D. Pp. 24.

Proverbial Treasury. English and Select Foreign Proverbs from Fifty-one Different Ancient and Modern Languages. By Carl Seelbach. New York: Seelbach Bros. 1880. No. 1., containing 4,900 Proverbs. 50 cents.

Actual Measures of the Great Pyramid of Egypt, disclosing the Architectural System employed. International Institute for preserving and perfecting Weights and Measures. Toledo Blade Printing Co. 1880. Pp. 19.

Studies from the Biological Laboratory of the Johns Hopkins University. No. 1. Session 1877-'78. No. 2, Session 1878-'79. Edited by H. N. Martin, M. A., D. Sc., Professor of Biology. No. 3, Chesapeake Zoölogical Laboratory. Scientific Results of the Session of 1878. Edited by Professor W. K. Brooks, Associate in Biology. 1879. No. 4, Development of the Oyster. By W. K. Brooks. Baltimore: John Murphy & Co. 1880. $1 each.

Camps and Tramps in the Adirondacks, and Grayling Fishing in Northern Michigan. A Record of Summer Vacations in the Wilderness. By A. J. Northrup. Syracuse, N. Y.: Davis, Bardeen & Co. 1880. Pp. 302. $1.25.

Dwelling-Houses: Their Sanitary Construction and Arrangement. By Professor W. H. Corfield, M. A., M. D. New York: D. Van Nostrand. 1880. Pp. 156. 50 cents.

A Series of Questions in English and American Literature. Prepared by Mary F. Hendrick. Syracuse, N. Y.: Davis, Bardeen & Co. 1880. Pp. 76. 35 cents.

Sea-Air and Sea-Bathing. By John H. Packard, M. D. Philadelphia: Presley Blakiston. 1880. Pp. 124. 50 cents.

Post-Mortem Examinations. By Professor Rudolph Virchow. Translated from the second German edition. By Dr. T. P. Smith. Philadelphia: Presley Blakiston. 1880. Pp. 145. $1.25

Common Mind-Troubles and the Secret of a Clear Head. By J. Mortimer-Granville, M. D., etc. Edited, with Additions, by an American Physician. Philadelphia: D. G. Brinton. 1880. Pp. 185. $1.

The Hair: Its Growth, Care, Diseases, and Treatment. By C. Henri Leonard, M. A., M. D. Detroit: C. Henri Leonard. 1880. Pp 316. $2.

Free Land and Free Trade. By Samuel S. Cox. New York: G. P. Putnam's Sons. 1880. Pp. 126. $1.25.

Radical Mechanics of Animal Locomotion. By William P. Wainwright. New York: D. Van Nostrand. 1880. Pp. 294. $1.50.

Silver in its Relation to Industry and Trade. By William Brown. Montreal: Lovell Printing Co. 1880. Pp. 134. 60 cents.

Life: Its True Genesis. By R. W. Wright. New York: G. P. Putnam's Sons 1880. Pp. 298. $1.50.

Practical Keramics for Students. By C. A. Janvier. New York: Henry Holt & Co. 1880. Pp. 258. $2.50.

A Guide to Modern English History. By William Cory. Part I., 1815 to 1830. New York: Henry Holt & Co. 1880. Pp. 276. $2.

Schiller's Complete Works. Edited, with Careful Revisions and New Translations, by Charles J. Hempel, M. D. In Two Volumes, with Illustrations by the Best German Artists. Philadelphia: G. Kohler. 1879. Cloth, .

POPULAR MISCELLANY.

Climate and Complexion.—Correction.— Messrs. Editors: I notice that in my article on "Climate and Complexion," published in your May number, I have, either in so many words or inferentially, made the statements that a dark pigment reflects the rays of light and heat better, and that it is a greater obstacle to their transmission than a light one. These, of course, as they stand, are quite wrong. What I should have said is, that a cuticle containing a dark pigment is less permeable by heat and light, because it is thicker and more opaque. For some reason, which I do not undertake to explain, the coloring matter of the skin, when abundant, is darker than when scanty. Hence, a cuticle containing a dark pigment is less transparent. And because abundance and consequent blackness of the pigment imply thickness of the cuticle, a dark cuticle does not transmit heat so readily as a light one.

J. M. Buchan.

Barrie, Ontario, Canada, *May* 3, 1880.

Summer Schools of Natural History.— We received, too late for insertion in our May number, the announcement of this summer's session of the Chesapeake Zoölogical Laboratory, which was to open April 22d at Beaufort, North Carolina, and continue until the 1st of September, under the direction of W. K. Brooks, Assistant Professor of Zoology and Comparative Anatomy in Johns Hopkins University. The house to be used as a laboratory is near the water, and the equipment includes boats, nets, dredges, aquaria, books, microscopes, and all the necessary appliances for collecting and studying marine animals and plants, and a steam-launch for dredging and surface collecting.

The fifth session of the Summer School of Biology at Salem, Massachusetts, will be held at the museum of the Peabody Academy of Science, Salem, under the direction of Professor Edward S. Morse. Professor George L. Goodale has kindly consented to give six lectures on physiological botany. The other instructors are Mr. John Robinson, cryptogamic botany; Mr. John H. Sears, analytical botany; Professor H. H. Straight, anatomy and physiology of the vertebrates;

Mr. Charles Sedgwick Minot, embryology; Mr. Charles Fish, entomology. Mr. Morse will lecture on the invertebrates. The school will commence July 6th, and continue six weeks. It is designed expressly for teachers.

A Summer School of Biology will be opened at Drury College, Springfield, Missouri, on July 1st, to continue not less than six weeks. The course is designed mainly for teachers; and lectures, laboratory study, and excursions will be the chief means employed for carrying on the work. Mr. E. M Shepherd, of Drury College, will instruct in the departments of Invertebrate Zoölogy and Cryptogamic Botany; Mr. C. H. Ford, of the State Normal School, is to have charge of Vertebrate Zoölogy and Phænogamic Botany; Mrs. H. C. Milner will give instruction in methods of teaching Elementary Science; and Dr. T. U. Flanner will instruct in Microscopy.

Rearing Silkworms in England.—Mr. Alfred Wailly contributes to the "Journal of the Society of Arts" some valuable notes on silk-producing bombyces which were bred in England during 1878. The *Attacus Yama Mai*, or Japanese oak silkworm, is difficult to rear, since it is in the egg state in the winter. The eggs have to be kept protected from the rain and the rays of the sun, and a special provision of young oak-trees which have been potted and protected from the frost, not forced, is recommended in case they hatch out too soon. The *Attaeus Pernyi*, or Chinese oak silkworm, is very easy to rear in the open air, and will feed, like *Yama Mai*, on all species of oak. The young worms of the first brood hatch in June or the beginning of July, when there is an abundance of foliage to feed them. The species is reproduced with great facility. The hatching of the second brood in the fall should be prevented by keeping the cocoons in a cool place. *Attacus cynthia*, or the ailantus-worm, will feed, but not as well as on the ailantus, on the laburnum, lilac, and cherry. *Attacus Atlas* feeds on the apple, plum, peach, barberry, etc., and seems to have been reared with success. *Attacus Selene*, a "magnificent species" from India, was introduced into Europe in 1878. The raising of it is apparently hazardous, for, though there were plenty of ova, and they hatched out well, many of the larvæ died in the last stage. A good account is given of the *Attacus polyphemus* and *Attaeus cecropia*, from North America, which thrive well on a variety of plants.

About Beer.—An account of the production and consumption of beer throughout the world is given in the work of Mr. Von der Planitz on "Beer," which we have already noticed. The scientific investigations which have been made on subjects relating to fermentation have led to improvements in the processes of manufacture, and to the establishment of numerous schools or departments of schools in Germany and other countries where these subjects are specially studied. The foundation of a brewers' school in the United States has been talked of since 1871, and was one of the subjects considered at the Brewers' Congress held during the Great Exhibition at Philadelphia in 1876; but it has not yet taken shape. A considerable library of books relating to the practice and science of brewing has been published, and journals devoted to the business and the art are printed in Germany, Austria, Bohemia, France, England, and the United States. A number of scientific and experimental stations and laboratories have been established in Germany, where special researches are still carried on. A consolidation of works for brewing seems to be going on in all countries, so that the steady increase in the production of beer is attended by a decrease in the number of breweries. This feature is, however, common to most contemporary industries. Great Britain leads all other countries in the manufacture of beer, as well as in the production of barley, but returns a smaller production of hops than Germany. Germany is not far behind it, while the United States stands third in the list, and is followed by Austria, Belgium, and France. Belgium produces the largest quantity (149 quarts) per head of the population, and Great Britain (143 quarts) next. Germany (94 quarts) holds the third place by this criterion, and the United States (38 quarts) the sixth, being surpassed by Denmark and the Netherlands. The statistics of single states in Germany and of the Austrian Empire indicate that the amount of beer produced in those countries has about tripled within the last forty years. The production of Great Britain increased from 7,670,100 barrels in 1830 to 25,336,811 barrels in 1870. It consists chiefly of the ancient amber-colored ale and the modern dark-brown porter. The Belgian beers are the mars, a thin beer; the lambic, a strong and light-colored drink; and the faro, which the retailer himself prepares by mixing the other two kinds. The production of France has more than doubled since 1842. A strong lager-beer and a weaker small-beer are most in favor, and the foreign beers are in common use. The principal consumption is in the north, the people of southern France inclining more to wines. The same is the case in Italy, where a light, highly-fermented beer is produced, and a considerable quantity is imported from Austria; but no beer is used south of Naples. The manufacture and consumption of beer are increasing very rapidly in Russia, and a great deal is imported into that country from Austria and England. In Sweden and Norway nearly every man brews his own beer at home. No lager-beer was made in the United States forty years ago. In 1876 the President of the Brewers' and Maltsters' Association asserted that it was the great national drink which was to drive out whisky, and that there were 2,783 breweries, employing 35,400 hands, and producing 330,600,000 gallons. In all Europe and America 63,631 breweries produce yearly more than 3,480,000,000 gallons of beer.

Dampness and Diphtheria.—The opinion that a close connection exists between diphtheria and dampness of site is confirmed in some English reports recorded by Dr. Woodforde. In an outbreak of diphtheria at Purley in 1878, the cottage in which the earliest cases occurred was much shut in by trees, and, although it was very clean, it was damp and insufficiently ventilated, especially in the sleeping-rooms, it was exposed to the emanations of the cess-pit, and the water was not pure. At Ramsbury, where diphtheria was unusually fatal in 1877 and 1878, the ordinary sanitary defects were not much worse than in other villages, but the sites of many of the cottages were almost level with the river, and damp, with the subsoil water very near the surface. At Clifton-Hampden, where diphtheria had occurred for several years in succession, the ordinary defects of porous cess-pits and polluted water were noted, though not to so great an extent as at other places where there had been no diphtheria, but the village also appeared damp, and a stagnation of air was evidently occasioned by the number of trees adjoining the cottages. Sanitary improvements were instituted, the trees were thinned out, and a gale took away some that had been left, and the disease has not appeared in the place since.

Features of the Central Arabian Desert.—Mr. W. S. Blunt read a paper, last December, before the Royal Geographical Society, on a journey he had undertaken during the preceding winter from Damascus to the Jebel-Shammar, in the region of Nejo in Central Arabia, in which he passed through a country that no European had visited since the journeys of Mr. Palgrave and Colonel Pelley in 1863 and 1864. On his way he traversed the red, sandy desert of the Nefud. Here he observed a strange phenomenon, which he describes as the only feature of the tract. The whole surface of the plain is pitted with deep horseshoe hollows, called by the Arabs *fulj*, which are shown to be permanent in site and conformation by the shrubs and bushes which line their sides, and by the tracks which cross and recross each other in such of them as are frequented by sheep. They are absolutely uniform in shape, differing only in size, and are all set with great regularity toward the same point of the compass. In form they exactly reproduce the print of an unshod horse's hoof, the toe pointing westward and being marked by a steep declivity, while the bottom of the hollow slopes gradually upward to the heel, until it reaches the general level of the plain. The frog of the hoof is roughly represented by a number of shallow watercourses converging to the lowest point, the toe. Solid ground sometimes occurs at the bottom of the deepest of the pits. They vary in depth from twenty to two hundred and twenty feet, and in width from fifty yards to half a mile; the appearance of depth is often enhanced by a sand-mound at the western edge of the hole. As seen from the tops of the higher rocks, the *fuljes* "run in long, sinuous strings with a main direction generally corresponding with their aspect," which gives them still more the appearance of huge horse-tracks. This desert is provided with a vegetation of its own, and is well clothed in the hollows and most of the plain with shrubs. The plants include three grasses and "two considerable shrubs, almost worthy to be ranked as trees." The *ghatha*, growing sometimes to the height of twelve or fifteen feet, gives a bright, smokeless flame, and makes the purest charcoal in the world. The Bedouin tribes make their summer home here, living on the milk of their camels, and independent of water, and always finding pasture. Among the wild animals are the ostrich, hares, the ibex, the leopard, a marmot, snakes, lizards, hawks, buzzards, the bustard, and one or two smaller birds. A wild cow, or white antelope, related to the African antelopes, is native to the region. Tracks of this animal were seen at least a hundred miles from any place where it could have procured water, confirming the assertion that it never drinks. Of insects, the dragon-fly, beetles, ants, and the common house-fly were noticed. A specimen of the painted lady butterfly, famous for its long flights, was seen sunning itself on the rocks of Aalem. This insect could not have been bred at any nearer point than the hills of Syria, four hundred miles off.

Insect-Powders as Remedies for Flies and the Aphis.—The insect-powders commonly sold are the powdered flowers of different species of Pyrethrum. Of the two principal kinds, which are known as the Persian and the Dalmatian powders, the Dalmatian is the more energetic. The flowers, whether whole or powdered, preserve their activity for a long period. Samples, which have been kept for six months, show no depreciation. They may be used with much effect against house-flies simply by charging the room with the dust. Mr. William Saunders says, in the "Canadian Entomologist," that he has frequently, after having charged the air in his kitchen and dining-room at night, found all the flies lying dead on the floor in the morning. Few will escape when the room is closed for half an hour after using the powder. Mr. Saunders has also applied the powder with excellent success to the destruction of the green aphis in his greenhouses. The pests will fall to the ground when the dust is blown among the plants, and in the course of an hour or two the greater part of them will be found disabled; they seem, however, to be only stupefied, not killed, as the flies are, and must be taken care of. The powder gives a more convenient and pleasant remedy than any other that we have. It is, moreover, safe.

The Damposcope.—Professor Forbes has invented an instrument for detecting fire-damp and determining the quantity of light carburetted hydrogen in the air, which he calls the "damposcope." Its construction is very simple. Over the mouth of a straight brass tube is fixed a tuning-fork; inside the brass tube slides another tube of the same metal, which is moved by a regulating screw, so that the compound tube can be lengthened or shortened at will, and this movement is registered on a dial. To ascertain the amount of fire-damp in the pit, the instrument is taken to the suspected spot, the tuning-fork is set vibrating, and the screw is turned until the maximum sound is emitted. The index is then read off. It appears that the quantity of gas can be determined to within one half per cent.

A New Metallic Compound.—Mr. Granville Cole, Ph. D., recently described before the British Society of Arts a new metallic compound which possesses some remarkable and valuable qualities. Its preparation is based on the principle that the sulphides of metals combined with molten sulphur form a liquid, which, on cooling, becomes a solid homogeneous mass, possessing great tenacity, and having a peculiar dark gray—almost black—color. Nearly all the metallic sulphides will form, with an excess of sulphur, combinations which have the same properties. The combination used by Dr. Cole in illustrating his address was formed of an ore of iron pyrites containing lead and zinc sulphides. It belongs to the class of compounds known as thiates, or sulphur sulphides. The compound has the advantages of a low melting-point, 320° Fahr., of expanding on cooling, of resisting atmospheric and climatic influences better than marble or bronze, of superior resistance to acids, alkalies, and water, and of being susceptible of a high polish. A polished surface of the metal has been exposed for six months in all weathers without showing any change, and another specimen suffered but little from a month's soaking in *aqua regia*. By reason of its low melting-point it is easily prepared for the mold, and in consequence of its power of expanding it gives a nearly perfect cast. In the gelatine mold it yields an impression before the form of the mold is destroyed, and then, if the gelatine be allowed to remain on the metal till it is cooled, it remodels itself so as to be ready for the next casting. The compound, which is called Spence's metal, after its discoverer, Mr. J. Berger Spence, is useful for castings of all kinds, is better adapted than lead for the joinings of gas- and water-works, is suitable for vessels in which chemical processes not requiring a high temperature are to be conducted, and may be employed for joining railings to stones, for coating the holds of ships, for forming damp-proof shields in the walls of houses, for hermetically sealing bottles, for covering cloths, for preserving fruit and other articles of consumption, and to take the place of metal-lined boxes. For all these, and many other purposes, its cheapness and its general adaptability give it a great advantage, for its cost is calculated as only about one fourth that of lead.

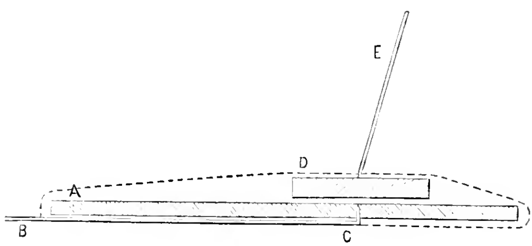
The Electric Light and Vegetation.—Dr. C. W. Siemens has recently conducted experiments for two months on the influence of the electric light on vegetation. He planted the quick-growing seeds of certain common hardy vegetables in pots, and divided these pots into four groups, of which one was kept in the dark, one was exposed to the influence of the electric light only, one to the influence of daylight, and one to the influence of the electric light and daylight in succession. The electric light was applied for six hours each evening, and the plants were left in darkness during the remainder of the night. The plants that were kept entirely in the dark soon died; those exposed to the electric light only, or to daylight only, throve about equally; and those exposed to both daylight and electric light throve better than either. The experiments showed that the electric light is efficacious in producing chlorophyl in the leaves of plants, and in promoting growth. It also appears from them that an electric light equal to fourteen hundred candles, placed at a distance of a little more than two yards from growing plants, is equal in effect to the average daylight of the English March. Other conclusions, which Dr. Siemens thinks he is justified in drawing from his experiments, are—that plants do not require a daily period of rest, but make increased and vigorous progress if subjected during daytime to sunlight and during the night to the electric light; that the radiation of heat from powerful electric arcs can be made available to counteract the effects of night-frost, and is likely to promote the setting and ripening of fruit in the open air; and that, while under the influence of electric light, plants can sustain increased stove-heat without collapsing. The expense of electro-culture, being dependent on the cost of mechanical energy, may be made very moderate where natural sources of such energy, such as waterfalls, are available. The buds of tulips, placed in the full glow of an electric lamp during the lecture in which Dr. Siemens related his experiments, expanded into full bloom in forty minutes. It is said that in India, where the bamboo throws up its shoots at the beginning of the rains, it rarely does so with vigor before the occurrence of a thunderstorm, and that its growth is more rapid as the thunderstorms are heavier.

A Test for Watches.—The corporation of Yale College have established an horological bureau in connection with the Winchester Observatory, for the purpose of encouraging improvement in watchmaking and pursuing researches in whatever may aid in the construction of refined apparatus for the measurement of time. In connection with this object they have provided apartments and made other arrangements for testing the running qualities, as to regularity, etc., of such timepieces as may be submitted for the purpose. Certificates of performance are given to the watches thus tested according to the standard of excellence they show. The apartments include a room of the ordinary temperature (65° to 75°), a cold room (40°), and a hot room (90°), and the watches are tested in the vertical and horizontal positions. Eight classes of certificates are given, corresponding with different combinations of the several tests and their relative duration. In cases where no certificate can be given the movement will be returned to the maker, with a statement of its performance.

Snakes and Snake-Poison.—Professor Huxley, in a lecture on "Snakes," at the London Institution last December, said that no creatures seemed more easily destroyed by man and few less able to defend themselves; yet there were not many animals gifted with so many faculties. The snake can stand up erect, climb as well as any ape, swim like a fish, dart forward, and do all but fly in seizing its prey. The destructiveness of snakes to man is illustrated by the fact that twenty thousand human lives are yearly lost in India by their poison, and it might safely be said that they are a more deadly enemy to our race than any other animals. The speaker pointed out some very curious arrangements in the anatomical mechanism and jawbones, illustrative of the statement that the snake can not properly be said to swallow his prey; he holds on to it rather, gradually working it down its throat in a most leisurely manner, but never letting it go. He requires a very fully developed and effective apparatus of salivary glands for this purpose. The poison-bag of the venomous snakes is nothing but a modification of the salivary glands of the harmless species, the structure of both kinds being in almost all respects not only parallel throughout, but almost identical. As another instance of the close relationship, it was shown that the sharp channel-needle which conveys the poison of the cobra and its congeners is nothing but the development of the tooth which these murderous reptiles possess in common with innocuous snakes. The fact that the salivary gland was the poison-laboratory of the deadly snakes, as well as the known properties of the saliva of dogs or other living creatures affected with rabies, appeared to Professor Huxley to point out the direction in which lies the solution of the difficult problem of the cause of snake-poisoning, and of a possible antidote against it. At present there was no man living who could heal the bite of the cobra, except by cauterization in very fresh cases. A fitting supplement to Professor Huxley's remarks is afforded by facts given in the reports of the Snake-Poison Commission of Calcutta, showing the number of snakes killed, and of deaths by snakes and wild animals in India. In 1875, 270,185, in 1876, 212,371 snakes were killed in all India. The deaths by snakes and wild animals were 21,000 in 1875, 15,946 in 1876. These figures do not give the whole numbers, for the registries are incomplete in the English districts, and no registries are kept in the native states, so that it may be found hereafter that many thousand deaths must be added to complete the catalogue of annual disaster from snakes. The excess of numbers in 1875 is accounted for by the fact that the floods of that year drove the snakes to the high-roads and exposed places. Remedies are said to be known for the poison of all the snakes except the cobra.

Development of the Limbs of Saurians.—Professor O. C. Marsh has noticed some peculiarities in the limbs of the sauranodon, the new saurian described by him in January, 1879, which give it a special interest. Both the anterior and posterior limbs are less specialized than in any other known vertebrate above the fishes. In the fore-paddle, the humerus alone is differentiated. Below this, the bones of the forearm, the carpals, metacarpals, and phalanges are essentially rounded, free disks, implanted in the primitive cartilage. The structure of the posterior limb is substantially the same. The most striking features of the limbs are the presence of three bones next below the humerus and the femur and articulating with them, corresponding apparently with the radius, intermedium, and ulna in the fore-limb, and with the tibia, intermedium, and fibula in the hinder limb, and the fact of six digits. These characters are held to mark a stage of development below that seen in any other air-breathing vertebrate, and only approached by the limb of the icthyosaurus. The intermedium seems, in the process of differentiation, to have been crowded out of its original position between the marginal bones of the second or epipodial series into the third or mesopodial series. In icthyosaurus, the intermedium is not entirely excluded from the third row; in plesiosaurus and all other reptiles the process is essentially completed. In some amphibians, the bone still separates the lower end of the two specialized bones above it. Sauranodon marks an earlier and most interesting stage in the differentiation, and indicates how the transition was accomplished. Some of the amphibians retain remnants of a sixth digit, and icthyosaurus often presents traces that represent lost digits; but with these exceptions the normal number of five digits is not exceeded in any other air-breathing reptile than sauranodon.

To pierce Glass with the Electric Spark.—In the usual process of piercing glass with the electric spark when the glass is thick, one of the wires has to be inserted in a bed of insulating resin, quite thick, and which has itself to be melted upon the plate of glass. The operation, involving the use of heat, is inconveniently long; and, besides, the trouble of cleaning the glass of the resin has to be gone through after the hole is made. The process described below by M. Fages, architect of the city of Narbonne, is easy of application, and requires only a few minutes for preparation and execution. The apparatus is so simple that any one can construct it for himself, and it may be used for an indefinite number of operations. The cut represents it in vertical section. It consists of—1. A rectangular plate, A, of hardened, black India-rubber, which should be, for a coil giving a spark of four inches, not less than six inches long and four inches wide; 2. A brass wire, B, the bent point of which, C, screwed or pushed into the India-rubber plate, rises even with its top. To use the apparatus, we lay it horizontally on a table, and put the brass thread B in connection with one of the poles of the magnetic coil; then pour some drops of



olive or other oil on the India-rubber plate above the point C, and put upon it the plate of glass D, which is to be pierced, taking care that no bubbles of air are inclosed. The oil causes the insulation of the point C. This done, connect the wire E with the other pole of the coil and produce the spark. It is very easy, by moving the glass along, to make a number of holes as close to each other as may be desired. The only precaution necessary is to have the India-rubber plate large enough—so large that it will not be possible for the spark to jump between the wires by following the routes indicated by the dotted lines.

An Electrical Railway.—Mr. Werner Siemens exhibited an electrical railway at the recent exposition in Berlin, with which he attained a fair degree of success in transmitting electrical power to a distance, and applying it to the movement of carriages. This apparatus consists of a dynamo-electric machine fixed in the station supplying force to a second machine placed on a locomotive-carriage and connected with it by the rails of the track and a third rail which is insulated in the middle of the track. The electrical current is transmitted from the generating machine to the locomotive through the middle rail, and is returned through the wheels and the rails of the track. The carriages to be drawn by the locomotive are all electrically connected with it, so that communication is established through all the wheels. The train exhibited by Mr. Siemens consisted of the locomotive and three carriages with seats for six persons each.

With this train and its eighteen passengers an effective force was gained equivalent to that of two horses. In the interior of the exposition building a force equivalent to that of three horses and a half was gained, and a speed of 7·8 miles an hour. Mr. Siemens, in giving an account of his invention to one of the societies a few months ago, did not seem to have much faith in its practicability, for he said he was afraid that "a great deal of water would run into the Spree before his dream would be realized," but his firm has since submitted to the city of Berlin a proposal for the construction of an elevated railway across a part of that capital, to be operated by his machines. A track is contemplated similar, in its elevation and relations to the street, to the tracks of the elevated railroads in this city. The carriages will be narrow and short, to contain ten sitting-places and four standing-places. The machine to propel them will be placed under the floor of the carriage between the wheels, and a steam-engine with sixty-horse power, which will be employed in the production of the electricity, will be placed at the terminus. A speed of about twenty miles an hour is anticipated. The magistrates of Berlin have appointed a special commission of engineers and architects to examine into and report upon the proposal.

Insects in Libraries.—Dr. H. A. Hagen, of Harvard University, has given in the "Library Journal" some observations on "Insect Pests in Libraries." The principal insects which our libraries have to dread are the larvæ of a beetle (*Anobium*), the same which is obnoxious to old furniture and picture-frames, which has been known for more than one hundred and fifty years, and the white ant. The beetle will eat through the thickest books, making a net-work of small passages, and, in some places, larger holes for its transformation. The white ants have been known for a long time in southern and western France, but did not appear especially injurious to books till about 1825, when they became very destructive. Some years later they did less damage, and at last disappeared without any apparent reason. These white ants exist in the United States, where instances of their destructiveness to books have been brought to notice in Springfield, Illinois, and in South Carolina. They are present at Cambridge, Massachusetts, in near neighborhood to buildings containing libraries. Mr. J. A. Lintner, of Albany, has noticed cases of cockroaches eating through the coating of the cloth binding of books stored in a basement; and the writer of this note has observed new books similarly injured by the common Croton-bug while they lay in a dry desk-drawer. The best remedy for insect depredations is constant use of the books. There are and must be in all complete libraries books which are used infrequently, and some which are very rarely used; and these afford good hiding-places for the larvæ of the beetle. They may be killed without hurting the books, by putting the books under the glass bell of an air-pump and drawing out the air. After an hour the larvæ will be found to be dead. Constant attention is the only remedy against the white ants.

Relics of an Ancient Race in Eastern New York.—Mr. S. L. Frey describes, in the "American Naturalist," some relics of an ancient race which he has found at a place he does not name in eastern New York. A number of arrow-heads, and a small copper awl, square and of regular shape, which may have been used for a drill, had been found before at the same place. He discovered two tubes bored in cases of steatite, a sea-shell adapted to use as a drinking-vessel, several bone awls, fragments of deer-horn implements, a gouge made of bone, implements of hornstone, beautifully chipped and of perfect proportion, and other articles usual in such places. In another grave, what had apparently been a necklace or head-dress, composed of copper and shell beads, was found. The copper beads had been made of thin sheets of copper rolled into tubes; the shell beads, which were from half an inch to one inch and three quarters in length, and of an average diameter of about half an inch, were made from the columellæ of large sea-shells rubbed and ground smooth, and drilled through their largest diameter. A similar necklace, but partly composed of small sea-shells, was found in another grave. The deepest grave was four feet deep, and contained one hundred and eighty-nine arrow-heads. It is especially mentioned that in two of the graves the bodies had been buried in an extended position.

A Chinese Hygieopolis.—According to Dr. W. Wykeham Myers, of the British Naval and Consular Service, Dr. Richardson has been anticipated in his "Hygieopolis," or city of health, and a city very like that which he has described as ideal is in existence at Wen-Chow, China. Dr. Myers is not prepared to say that the parallel is perfect, but observes that the similarity is so close as to warrant his alluding even to the high standard set up by Dr. Richardson. All the main and pleasant features of "Hygieopolis" above-ground were found at Wen-Chow, and even the deficiencies in the Chinese city did not prevent Dr. Myers from being surprised at the passing resemblance it presented to the ideal.

Animal Intelligence.—The following, cut from a recent issue of the "Portland Transcript," was sent to us by a valued correspondent, who vouches for its truth: "A friend gives us this dog-story as coming under his own observation: A bull-dog and a Newfoundland came into collision in Federal Street. The Newfoundland took to his heels for safety, and was closely pursued. Seeing that he was likely to be overtaken, he caught up a bit of dirt from the street, and at the critical moment dropped it as if it were something of value he was obliged to give up. The *ruse* succeeded; for the bull-dog stopped to pick up the supposed titbit, and the Newfoundland escaped. The disgust manifested by the vicious brute, when he found how he had been outwitted, is said to have been very comical."

Prehistoric Africa.—Dr. Emil Holub, the Austrian traveler, in a recent lecture before the British Anthropological Institute, on the central South African tribes, mentioned that he had found along the South African coasts clear traces of extinct tribes who, judging from their relics and from other indications, must have been of a very low type. Passing farther into the interior, there were evident relics of quite a different stage of culture, reminding him of the great African empire which the Portuguese marked on their maps as Monomatapa. Among them were workings of ancient mines, some even of gold, and the ruins of a rude kind of cyclopean fortifications. Such evidences, he held, pointed to exterminated tribes, and testified to the antiquity of the savage African rule of warfare, which destroys all the males, and allots the wives and children to the victors as slaves.

Production of Precious Metals in Colorado.—Mr. Frank Fossett, the author of a valuable work on Colorado, reports on the basis of his later observations, that that State has taken an immense stride forward in its mining industries during the past year, and has distanced California in the production of the precious metals. He believes that it will next year surpass Nevada and all other mining regions in the field of gold and silver. Full detailed statements have not yet been received from all quarters, but enough is known to make it sure that the return of the State for 1879 will amount to $18,650,000. The present rate of production is estimated at over $2,000,000 a month, with a prospect of a steady increase hereafter; and the entire product of 1880, it is believed, will be between $25,000,000 and $30,000,000. The product of last year consisted of $14,100,000 in silver, $3,000,000 in gold, $1,450,000 in lead, and $125,000 in copper.

The Carpet-Beetle.—Mr. A. S. Fuller contributes some notes to the "American Entomologist" on the habits of the carpet-beetle, whose larva is commonly called the Buffalo-moth, which may be of help in finding a remedy for the ravages of the insects. The larvæ feed on carpets and woolens, but the fully developed insects feed and pair out of doors, after which the female returns to the carpets to lay her eggs. Mr. Fuller found the beetles last summer feeding on the pollen of spiræas, catching them for several weeks on these plants, but on no others in his garden. As the spiræas are very abundant in all parts of the country, it would be easy to plant a number of them around the house as a bait for the beetles, where, by watching them carefully, the insects may be killed. The small flowering species seem to be preferred by the beetles, and are therefore recommended, as the goat's-beard (*Spiræa aruncus*), sorb-leaved (*S. sorbifolia*), and meadow spiræa (*S. ulmaria*). They are, moreover, desirable plants for their beauty.

NOTES.

Prior to the beginning of the eighteenth century opium was imported into China in comparatively small quantities, and mainly used as a remedy in dysentery. The vice of opium-smoking began in the latter half of the seventeenth century, but the drug was then too dear to permit the habit to spread rapidly; at the end of a hundred years, however, it had extended over the whole empire. The first edict against the practice was issued in 1796, and since then there have been innumerable prohibitory enactments, but all powerless to arrest the evil, which is now greater than ever before, and increasing in an alarming ratio.

M. Fautrat has been convinced, by his studies of the influence of forests upon the moist currents that pass over them, that pines and other needle-leaved trees have a strong attraction for the vapor of water. He believes that the resinous trees transpire twice as much as other trees; and has also observed that when they are exposed to moist air they absorb vastly more water than the latter.

The deaths have been recently announced of two of the most prominent entomologists of Continental Europe. Ernest August Helmuth von Kiesenwetter was a member of the Saxon Privy Council, an accomplished and conscientious worker in the science, a considerable traveler, and a close observer. He was chiefly a coleopterist, but attended more or less to all orders of insects, while limiting his studies chiefly to those of Europe. S. C. Snellen van Vallenhoven, of Holland, was best known by his works on the insects of Holland, and his "Entomological Fauna of the East Indies." He also produced a work, which is still incomplete, on the "Ichneumonidæ of Northwestern Europe." All of his works were illustrated by beautiful and faithful drawings from his own pencil.

Mr. Gramme is building for an establishment at Noisiel, France, a machine for transmitting electrical force to a distance, with which he expects to gain a normal power equivalent to that of ten horses, and under special conditions a power of sixteen horses.

The death is announced of Dr. Wilibald Artus, Professor of Philosophy at Jena, on February 7th last, aged seventy years. Also of Dr. Franz Xaver von Hlubek, Professor of Agriculture at the Graz Joanneum, on February 10th, aged seventy-eight years. In the third week of February also died Herr Adolf Müller, one of the directors of the well-known Geographical Institute of Justus Perthes at Gotha.

Careful investigation into the cause of the fire which broke out on the steamship Mosel revealed the fact that it originated spontaneously in silk goods which constituted a part of her cargo. Chemical examination showed that for every part of silk fiber "0·75 part of oxide of iron and 2·50 parts of coloring matter—consisting of fatty oils, organic and earthy matters—had been used to give weight and body to the silk."

From data obtained by a series of elaborate experimental researches, Professor F. Rosetti estimates the effective temperature of the sun at 9,965° centigrade, taking into consideration the absorption produced by the terrestrial atmosphere. But, estimating also the absorption of the solar atmosphere, and calculating the thermal effect of the sun if it had no atmosphere, the solar temperature would be 20,380·7° centigrade.

General William Munro, of the British army, and a learned botanist eminent for his thorough and comprehensive knowledge of the grasses, died at his residence near Taunton, England, on the 29th of January, aged sixty-four years.

The French Government has taken action with a view to the protection of the domestic birds of the country, prohibiting in the several departments the pursuit of other than birds of passage, and those only under certain limitations.

Recent official reports show that the adulteration of food and drugs has largely decreased in Great Britain under the operation of the legislation against it. In 1856, when the "Lancet" commission made a report of its inquiries on the subject, more than half the samples analyzed were found to be adulterated. The first analysis under the act of 1875 was made in 1877, when it was shown that of the samples subjected to analysis the proportion of adulterated ones had fallen to 19·2 per cent. In 1878 the proportion fell to 17·2 per cent. If spirits be excluded from the calculation, the percentage of adulteration would be represented by 15·5 in 1877, from which it fell to 13·7 in 1878.

The French papers chronicle the death, at the age of eighty-two, of Dr. Boisdoval, a distinguished horticulturist, and author of a valuable work on the insects which affect garden-plants.

KARL FRIEDRICH MOHR.

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THE INTERIOR OF THE EARTH.*

By R. RADAU.

THE additions that are being continually made to our knowledge of the composition and physical condition of the most distant heavenly bodies may well prompt one to ask why we are still so poorly informed concerning the constitution of the planet which the Creator has assigned to us for a dwelling-place. Mines and wells have barely scratched the solid crust that conceals the mysteries of the earth's depths. Our vague and uncertain ideas regarding the condition of the interior of the earth are based on analogies and inductions from facts observed on its surface or in the heavens. Very little light do we get on this subject from direct experiment. The bowels of the earth are not, indeed, easily accessible. Whatever the poet may say, the *descensus Averni* is not easily made; the domain of the stars is not thus hidden from us. For about two centuries large sums have been expended in the construction of gigantic telescopes with which to sound the depths of space; but no attempt, as a purely scientific undertaking, has been made to fathom the secrets of the underground world. The object of the numerous mines in different parts of the world has been simply the discovery of mineral riches, and the depths they have reached barely exceed, even in a few rare instances, a thousand metres; i. e., hardly the six-thousandth of the earth's radius—corresponding, on a globe thirteen metres† (about forty-two feet) in diameter, to a puncture one millimetre (about four one-hundredths of an inch) in depth.

Notwithstanding this paucity of positive data, it will not be unin-

* Translated from the "Revue des Deux Mondes," by Guy B. Seely.

† The length of a metre is about three feet three inches.

teresting to review the state of our knowledge on this obscure subject, and to show on what sides the question is accessible to science.

The form of the planets is itself an index, to a certain point, of the mode of their origin and their actual condition. These slightly flattened globes that wheel about the sun have been subject to the same laws that shape the drop of water and the grain of shot. It is impossible not to believe that they are specimens on a vast scale of the equilibrated form assumed by free fluid masses through the action of internal forces which assemble and unite their molecules. All these spheroids have been or still are liquid drops that have become flattened by reason of their rotary motion. Newton was led to infer the flattening of the poles from the idea that the earth had originally been in a liquid state, as the centrifugal force due to rotation tends to swell the equatorial at the expense of the polar regions. By the operation of the same force that impels a stone when swung in a sling to free itself, and that causes grindstones to burst when turned too rapidly, the particles of a revolving sphere tend to fly from the axis of rotation, and this centrifugal force, *nil* at the poles, increases as the equator is approached, and there attains its maximum intensity. The effect of this is to diminish weight, substances being a little less heavy at the equator than at the poles.

Imagine the earth completely liquid: the equatorial portion, driven by centrifugal force, will be elevated while the poles will be depressed. To better comprehend this, let us imagine a siphon, the two arms of which, joined at the center, issue, one at one of the poles and the other at the equator. The two liquid columns therein can remain in equilibrium, as the globe revolves, only on condition that the equatorial column, which is exposed to the action of centrifugal force, be longer than the polar column, which has lost nothing of its weight from this cause. The sphere becomes a flattened spheroid. This change of form can be demonstrated by turning rapidly on its vertical axis a sphere of clay or of flexible steel circles, as used in illustration of physics. As the pliant mass solidifies more or less completely, this flattened form is preserved.

That there is a discrepancy between weight at the equator and at the poles, more marked as we approach or recede from one or the other, may be shown by noting, by the tension of a spring, the weight of the same mass under different latitudes; but a more positive means of ascertaining this fact is furnished by the oscillations of the pendulum, which are retarded as the force of the earth's attraction diminishes. The astronomer Richer, having been sent to Cayenne in 1672 to observe the planet Mars, remarked that a timepiece regulated at Paris lost ten and a half minutes daily at Cayenne. It was this circumstance, at first inexplicable, that led Newton to suspect that the earth was a flattened spheroid.

It will be evident that an exact knowledge of the figure of the earth has an important bearing on any hypothesis of the internal constitution of our planet. Geodesy, that science that may be called surveying on a grand scale, and which takes for its bases of measurement at once the earth and the heavens, has not yet completed its work. Since the labors of the Abbot Picard, to whom we owe the first measurement of a meridional degree, and the celebrated voyages of Bouguer and La Condamine to Peru, and of Maupertuis to Lapland, which confirmed the supposition of the flattening of the earth, there have been many other immense labors of a similar kind all over the world. The Société Géodetique Internationale, organized some years ago, is occupied in compiling and perfecting the results of these researches, and in deducing therefrom a provisionally definite result. We know with certainty that the form of the earth is not greatly different from that of a perfect sphere, for the flattening ascertained by geodetic measurements is, in round numbers, equal to $\frac{1}{300}$, from which it follows that the equatorial radius does not exceed the polar by more than twenty-two kilometres* (a little less than fourteen miles). This number, which represents the amount of the equatorial swelling, is equal to four and a half times the height of Mont Blanc, but, on a ball thirteen metres in diameter, the twenty-two kilometres in question would make an inequality of only two centimetres (about three fourths of an inch), and this would be totally imperceptible to the eye. The natural inequalities of the earth's surface are comparatively insignificant; the Alps and Himalayas, on a ball thirteen metres in diameter, would be represented by projections of a few millimetres only, and the greatest ocean-depths would not exceed one centimetre.

The question of the true figure of the earth is one of the most difficult of problems. From the time of Newton it had been held that the earth was a revolving ellipsoid—in other words, that the meridians were ellipses, and the equator and all the parallels true circles; and it only remained to determine the ellipticity of these meridians, all being supposed alike. It is now twenty years since Captain Clark's calculations, based on the uniformity of the great triangulations made up to that period in various parts of the world, led to the conclusion that the equator itself has an elliptic form, and that, consequently, the meridians are ellipses unequally flattened. According to Clark, the equatorial flattening is $\frac{1}{3270}$, or about one tenth of the average flattening of the meridians. This depression, amounting to two kilometres, occurs under the meridian passing, in the east, through the Sunda Archipelago, and in the west through the Isthmus of Panama, while the enlargement occurs under the meridian of Vienna, crossing central Europe and Africa. Thus, according to the calculations, the world is an ellipsoid with three unequal axes. This supposition can be made to harmonize with the hypothesis of the primitive fluidity of the earth, the form in question being one of those assumed by free liquids in

* The length of a kilometre is about five eighths of a mile.

rotation. It was found, however, that Clark's calculations were considerably affected by certain anomalies probably existing in some of the geodetic calculations employed, and it seems that a majority of those competent to judge in these matters endorse the theory of a revolving ellipsoid.

By the term "figure of the earth" is understood the geometrical form of an ideal surface coinciding with the mean level of the sea, and prolonged in thought beneath the continents. In fact, geodetic calculations are always reduced to the sea-level, the altitudes of the stations being first determined from levels based on the nearest coast-line. The great difficulty is to accurately determine this level for a given station. For a long time it was supposed that the surface of the open sea was a horizontal; in other words, that it was parallel to the surface of liquids in repose, and perpendicular to the direction of the plummet-line. But this definition is insufficient, as may easily be shown. The apparent vertical indicated by the plummet-line or determined at the level of the sea, is simply the direction of weight, which may be materially affected by local attractions due to an irregular distribution of the masses composing the soil. The vicinity of a mountain will deflect the plummet to a considerable degree, and a subterranean cavity may cause a deflection in the opposite way.

Let us now imagine the continents divided by a network of canals that connect all the seas, thus making of them one continuous sheet of water, as it were. Setting aside, for the purpose of the illustration, the oscillations caused by the tides, this sheet of water, assumed to be immovable, which represents the mean level of the sea, will exhibit elevations and depressions attributable to the local influences that deflect the plummet-line. The attraction of the continents causes a notable elevation of the sea-level along the coast, and a proportionate lowering of the mid-ocean. This influence of continents was described by M. Saigey in 1842, who gave as the probable height of the sea on the coasts of Europe thirty-six metres. Seven years later Mr. Stokes, the celebrated English physicist, attacked the question, bringing to bear upon it all the resources of mathematical analysis; and Philipp Fischer, in 1868, estimated that the disturbance of level due to the attraction of continents might amount to nine hundred metres. The mean level of the sea is, therefore, in all probability, an irregularly undulated surface, and the ideal or geometrical surface of the earth a regular spheroid, deviating but little from this average level, the accidental irregularity of which is in some way equalized.

The triangulations by which the terrestrial arcs are measured define the dimensions and configuration of this spheroid by the comparison of distances measured on the earth with the corresponding angular amplitude ascertained from the astronomical latitudes and longitudes of the stations. The most delicate part of the operations consists in ascertaining the local attractions that cause the deviations of the plummet. This difficulty is felt particularly in the Russian and Indian triangulations. While Colonel Chodsko found in the Caucasus a deflection of fifty-four seconds, and Schweitzer, in an open plain in the environs of Moscow, deflections of eight and nine seconds, the Himalayan chain appears to have had but an insignificant influence in place of the considerable one which the theory required—as if these mountains were composed of less dense rocks than the soil of the plain.

The operations referred to serve to indicate the form of the earth by the angles which the verticals of a series of stations—i. e., the direction of weight—make with the earth's axis. Another mode consists in measuring at numerous points the *degree* of the weight, and from this the distance to the center of the earth, the rate of oscillation of the pendulum being also noted. These oscillations are accelerated as the attractive power of the earth increases—that is, as the center is approached. We have seen that Richer remarked these variations of the pendulum in his voyage to Cayenne, and that Newton furnished the explanation of the phenomenon. At the commencement of the present century Biot, Sabine, Kater, Lütke, Foster, and others, made numerous experiments of this nature which have furnished a valuable verification of the results of geodesy, properly so called. But it must not be forgotten that the degree of weight may be changed by the same causes that change its direction. A local accumulation of very dense rocks may increase the terrestrial attraction, and light ones may diminish it. The de-leveling of the ocean of which we have spoken, by which the waters near continents are elevated while the mass of the ocean at large is lowered, results in making an ocean-valley, as it were, from which the islands, that are thus nearer the earth's center than the continents, project. This will explain the increased rate of oscillation of the pendulum observed in many islands, which is otherwise inexplicable.

The perturbations to which the direction as well as the degree of weight is subject have enabled us to determine the earth's mean density. The principle of the method is easily comprehended. Let us suppose that the deflection of the plummet has been measured near an isolated mountain whose volume and weight it is possible to estimate with some degree of precision. The amount of the deflection will furnish a means of calculating the relation of the mass of the mountain to that of the earth, and, the two masses being known, their relative densities can then be determined. The oscillations of the plummet at the summit and at the foot of the mountain afford the basis for a similar calculation. On carrying the plummet to the top some oscillations per day will be lost, the distance from the earth's center being increased; but the mountain's own attraction in part offsets the decrease in weight attributable to altitude, and herein we have the means of comparing its mass with that of the earth.

These methods were not neglected by Bouguer in his voyage to

Peru. Aided by La Condamine, he observed the variation in the plummet-line due to the influence of Chimborazo, and he noted the rate of the pendulum's movement on the volcanic mountain of Pichincha (which is equal in height to Mont Blanc), and at the sea-level. Unfortunately, the imperfection of his instruments, the rigor of the climate, and the violence of the winds, prevented the two French astronomers from attaining great precision in these observations. The effects they had expected to see confirmed were found to be much less marked than they had anticipated, and Bouguer therefore believed that the volcanic mountains of Peru were hollow and internally simply huge caverns. A repetition of his experiments, with the care required in researches of such a delicate nature, would determine the question whether the unsatisfactory character of his results was due to errors of observation, or if it was a case similar to that of the Himalayan chain.*

Bouguer's method was employed successfully in 1774 by the celebrated English astronomer Maskelyne. He chose for his experiments Mount Schiehallion in Scotland. This mountain is wholly isolated. Its geologic constitution is known, and its form is not very irregular ; the calculations were thus simplified. By observations of the stars that passed near his zenith Maskelyne first determined the latitudes of two stations, one to the south and the other to the north of the mountain—the distance between them being 1,330 metres. The difference in the two astronomical latitudes was found to be 43″ instead of 54″.6, as shown by the measured distance. The excess of 11″.6 represented the sum of the attractive force exerted by Schiehallion on its opposite sides. It then remained to ascertain the volume of the mountain, its exact configuration, density, and total weight, and by the aid of these factors to determine the theoretic sum of the attraction it exerted on the plummet of the two stations. The geologist Hutton was intrusted with this work, which occupied him three years. The result of his calculations was, that the deviation observed would be explained by supposing the mean density of the mountain to be to that of the earth as 5 is to 9. Hutton first adopted for the density of Schiehallion the number 2·5—about the density of quartzose sandstone ; according to this the mean density of the globe was 4·5. He afterward modified these figures, taking 3·0 for the density of the mountain and 5·4 for that of the earth. The geological study of this mountain, undertaken subsequently by Playfair and Lord Webb-Seymour, showed the density of its component rocks to be intermediate between these two estimates, from which it would appear that the earth's density is 4·7.

These experiments were not supplemented by observations of the

* M. Saigey has shown that, by selecting from Bouguer's observations those which appear to have been made under favorable conditions, and by calculating the force of the attractions in a more exact manner, the density of the earth is found to accord with Maskelyne's estimate of it.

pendulum's oscillations; it is true the mountain's slight elevation—one thousand metres—did not promise a very marked effect. An experiment of this kind was made in 1821 by the astronomer Carlini, on Mont Cenis, which showed the earth's density to be in the vicinity of the number given by Maskelyne. In 1854 Airy performed an analogous experiment at the bottom of the Harton coal-mine. At a depth of 1,220 feet it was demonstrated that the seconds pendulum advanced in speed two and a quarter seconds per day, and from this it was concluded that the mean density of the globe is to that of the surface as 2·63 to 1, and, taking the density at the surface to be 2·3, that of the globe is 6·1. M. Saigey endeavored to find the density of the globe by the deflection of the plummet-line due to a whole continent's attraction, calculating the theoretic deviation from the vertical at Evaux, a central point of France, and one of the stations of the meridian of Paris. According to Puissant's calculation, there exists between the astronomical and geodetical latitudes of Evaux a difference of about 7″, which would indicate that the attraction of the southern part of France, i. e., to the south of the latitude of Evaux, exceeds that of the northern portion. Now, with a good orographic chart the average elevation of the ground from about Evaux to the Pyrenees, the Alps, and to the neighboring seas can be calculated, and with these data the effect of all the partial attractions that affect the plummet-line at Evaux. M. Saigey has shown that, to account for the discrepancy pointed out by Puissant (who supposes the attraction of the globe to be about 30,000 times greater than that of all France above Evaux), the mean density of the earth must be to that of France alone as 1·7 is to unity. Taking 2·5 for the density of the ground, as compared with water, it gives 4·25 as the density of the globe.

The researches of Maskelyne, above referred to, may be reduced to a closet experiment: one can weigh the earth in his own room! This was first done by the illustrious Cavendish. This, the youngest, son of the Duke of Devonshire, who sacrificed his hopes of fortune to his love of science, commenced his career in poverty. "His parents," M. Biot tells us, "seeing that he was good for nothing, treated him with indifference, and gradually became estranged from him. He made amends by becoming one of the first chemists of his time, and, when he had acquired celebrity, one of his uncles, who had been a general abroad, returned at a happy moment to leave him an inheritance of three hundred thousand francs rental. He also left him at his death a fortune of thirty million francs. Cavendish was thus the most wealthy of all the learned, and probably the most learned of all the wealthy."

Cavendish had received from Hyde-Wollaston an apparatus which he in turn had obtained as a bequest from John Michell, and which was designed to determine the weight of the earth by the attraction exerted by two large globes of lead on two small balls suspended from the ends of a movable lever. There was certainly something novel and *bizarre* in this idea of attempting to observe the attraction of a ball of lead, which we are accustomed to consider an inert mass—in trying to demonstrate by *sight* its infinitesimal share in universal gravitation. It was accomplished, nevertheless. Cavendish improved Michell's apparatus by applying to it the principle of the famous torsion balance of Coulomb—the torsion of a wire opposed as a moderate force to the attraction exerted on a lever carried by the wire. His experiments were communicated to the Royal Society of London in 1798. The mode of making the observations is easily described. A horizontal lever of fir-wood was suspended to a metallic wire dependent from the ceiling of a closed chamber. At its two extremities were two small balls and two blades of ivory, marked with divisions. All the movements of the lever were observed from without through lunettes fixed in the walls of the chamber, and directed toward these divisions. Finally, two large globes of lead, each weighing 158 kilogrammes and sustained by a screw-gauge, could be moved toward or from the balls at will, by mechanism worked from the outside. Now, whenever they approached the small balls the latter were seen to obey the attraction of the globes of lead; they were displaced, and oscillated around a new point of equilibrium where the reaction of the torsion wire counterbalanced the attraction of the globes. From these experiments and the ascertained strength of the attraction of the globes in relation to their weight, it is easy to estimate the relation of the mass of the globes to that of the earth, and thence the density of the earth. Cavendish thus found the earth's density to be 5·48, that of water being unity.*

Cavendish's experiments were repeated by F. Reich, at Freiberg, in two trials in 1837 and 1849, and also at London in 1842, by Francis Baily, under the auspices of the Astronomical Society. Reich's figures differed but little from Maskelyne's (5·44 to 5·58). Baily's experiment gave a little larger figure (5·67). Baily improved upon the apparatus of Cavendish in several ways: he changed the size and material of the small balls, using balls of platinum, lead, brass, zinc, glass, and ivory. The figure he settled upon was the average of over two thousand tests; still, it is not wholly reliable, his results being affected by certain errors the cause of which was for a long time unknown. The question was of an importance that warranted a re-examination of the data with all the resources of modern science. Two French physicists, A. Cornu and J. Baille, have recently accom-

* The considerable difference between this number and that furnished by Maskelyne's observations induced Hutton, then advanced in age, to examine anew Cavendish's experiments. "I could not," he says, "rely on these results without repeating the entire computation. Still, after a long life spent in abstract researches, being now eighty, and overwhelmed with infirmities, I feel that I may be pardoned for shrinking from the task. But I should have no rest were I not myself to undertake the work." Hutton discovered many small errors in calculation, and he found 5·31 to be the measure of the earth's density.

plished this work. Their experiments, commenced in 1870, have been the subject of various interesting communications to the Academy of Sciences. Their apparatus are deposited in the vaults of the Polytechnic School. They are much smaller than those of Cavendish and Baily, for, as Messrs. Cornu and Baille have remarked, there is an advantage gained in these experiments by reducing the dimensions of the apparatus. The attracting mass, formed of mercury contained in two hollow spheres of bronze, 0·12 metre in diameter, weigh twelve kilogrammes. By transpiration the mercury can be made to pass from one sphere to the other, thus doubling the effect of the attraction, and this change is effected without shock or disturbance.* The lever of the torsion-balance is a little tube of aluminium, 0·50 metre in length, carrying at each end a ball of copper weighing one hundred and nine grammes. A flat mirror fixed in the middle reflects the divisions of a horizontal scale five or six metres distant, and the slightest movement of the lever is thus revealed by a displacement of the scale divisions. The time of a double oscillation of the lever is about seven minutes. The phases of these oscillations are registered by electricity. A great merit of these researches consists in the opportunity they afford for a thorough study of all the causes of perturbation that can introduce error into such experiments. The definite result can be accepted with confidence. The figure thus far obtained is 5·56. It may be added that Messrs. Cornu and Baille have discovered the cause of the too large number given by Baily. In correcting the errors of system in his experiments, it is probable that a slightly different number will be obtained—5·55. To sum up, the earth's mean density thus appears to be five and a half times that of water, and the density at the surface is less than half that of the interior, or about 2·5. Consequently there must be in the interior heavy masses whose excess of density compensates for the lack thereof in the rocks at the surface. This need not be surprising, for the heavy pressure sustained by the deeper strata must naturally increase the density. But what is the law governing this increase of density from surface to center? Legendre formulated a simple law, adopted also by Laplace, according to which the surface density is 2·5, at the middle of the radius 8·5, and at the center 11·3, the mean being taken as 5·5. A different law, to which M. Edouard Roche arrived by theoretic considerations, gives a surface density of 2·1, a mid-radius density of 8·5, and 10·6 at the center. This agreement of results deduced from three different hypotheses shows that the decision of the question is narrowed to small dimensions. Adopting M. Roche's conclusions as the most probable, it can be said that the mean density of the earth is about double that of its surface, and that the density of the center is double that of its mid-radius. The central strata or masses have a density approximating to that of lead.

* In the later experiments the number of the spheres was doubled.

The fact of an elevated temperature in the depths of the earth can no longer be doubted, though the law according to which the heat increases as we descend below the surface is still far from being perfectly understood. As early as the seventeenth century Father Kircher mentions the subterranean heat that was felt at the bottom of mines.* Boerhaave and Boyle also make mention of observations concerning the heat existing in the center of the earth. Still, it was not until 1740, nearly a century and a half after the invention of the thermometer, that a serious attempt was made to measure this heat. This was first done by Gensanne, director of the lead-mines of Giromagny (Vosges), who lowered a thermometer to a depth exceeding four hundred metres, and proved that the temperature increases at the rate of one degree to nineteen metres. Toward the end of the century Horace de Saussure, desiring to ascertain whether the earth's proper heat had any effect on the melting of glaciers, made a similar experiment in the salt-mines of Bex, and found the rate of increase to be 1° to 37 metres. Many similar experiments have since been made; it will suffice to cite the most important.

Cordier, in his celebrated "Essay on the Temperature of the Interior of the Earth," read at the Academy of Sciences in the year 1827, compiled the results of his predecessors' researches in this matter and those obtained by himself in certain mines. In the mines of Carmeaux (Tarn) he found an increase of 1° to 36 metres, 1° to 19 metres in the mines of Littry (Calvados), and 1° to 15 metres at Decize (Nièvre). The average of his compilations is 1° to 25 metres. From these investigations he concluded that at a depth of some hundreds of kilometres the heat must be 100° of Wedgwood's pyrometer—sufficient to fuse lava.

To arrive at trustworthy results, it is not enough to observe merely the temperature of the air at the bottom of a mine, or that of the water that penetrates the adits, but the thermometers should be placed in cavities made in the natural rock, and left there a sufficient length of time to allow them to acquire the temperature of the surrounding medium. The currents in the air of mines lower the normal temperature, particularly by producing an evaporation of the moisture in the rock, and it thus happens in some mines that the temperature of the air is lower than that of the surface-air, as is the case in the Maestricht quarries. The heat due to the presence of workmen modifies the effect of this in a measure. It is estimated that in a gallery 4,650 metres long, and two metres high by one wide, the temperature will be raised 1° by ten men, each furnished with his lamp. As regards the water found in the adits, it is evident that they will not indicate the mine's true temperature unless they remain in it for a considerable time, for the water infiltrated from the surface, or coming from springs at certain depths, may be either warmer or colder than the rocks

* "Mundus Subterraneus," 1664, vol. ii.

through which they percolate. The most reliable way, therefore, is to place the thermometers in cavities of the rocks in the mines, and also in the angles of the cuttings, where the rock is newly hewed, and still uncooled by contact with the air. Cordier pierced the rock for this purpose to a depth of 0·65 of a metre. Reich, who made a large number of observations in the mines of Erzgebirge, bored to the depth of a metre, using thermometers constructed for the purpose, with long stems projecting from the orifices in the rock, which were then packed with sand. These investigations were continued from 1830 to 1832, in twenty different mines, scattered over many square leagues. The thermometers were ranged as far as was practicable in a vertical line, at depths varying from 20 to 350 metres, the markings being taken twice or thrice weekly. From these observations it was found that the depth corresponding to an increase of 1° Cent. was 42 metres.* In the Ural mines in Siberia, Kupper showed that a far more rapid rate of increase existed—1° to 20 metres—while in the mines of Prussia the rate was found to be much less rapid—1° to 57 metres, according to Gerhard. In certain isolated cases a far greater divergence is seen. It, moreover, appears to be established that the heat increases more rapidly in coal-mines than in metal mines, and in copper than in tin mines, and in the metalliferous rocks generally more rapidly than in the schists, while in granite the increase is more gradual than in any of the preceding. These differences are no doubt due to the greater facility with which certain earths conduct heat, and perhaps to chemical phenomena of which they are the seat.

It must also be said that in many cases the rate of increase, far from being uniform, appears to slacken as the greater depths are reached. Thus, according to Fox, the observations made in the Cornwall and Devonshire mines show a difference of 1° Cent. to 15 metres, down to a depth of about 100 metres, and 1° to 41 metres at a depth of 350 metres. This decrease is also very marked in the famous Tcherguine pit in Yakutsk, which is in completely frozen soil. Commenced in 1848, at the expense of a merchant named Fedor Tcherguine, who expected to find water at a depth of 10 metres, this pit was sunk in three years to a depth of 35 metres, still in frozen ground, and the work would have been abandoned if, happily for science, Admiral Wrangel, on a voyage to Yakutsk, had not represented to the proprietor the interest the undertaking would have in its bearing on the physics of the globe. It was therefore excavated for six years more, reaching a depth of 116 metres. Even there the earth was still frozen, and the work was finally abandoned in 1837, and the pit was carefully covered. In 1844 Middendorf visited it, and made a series of thermometric observations, according to which the mean temperature was found to be, at a depth of two metres, 11·2°; at 60 metres, 4·8°; and

* Only those observations made below twenty metres from the surface, where the temperature does not vary with the seasons, were taken into account.

at the bottom, 116 metres, 3°. It was thus seen that, whereas the rate of increase from the surface to 60 metres in depth was 6·4°, for the remainder of the depth, 56 metres, it was only 1·8°.

The experiments made in artesian wells have given analogous results—that is, wholly irregular as regards the rate of increase of temperature. The mean of 27 observations in Vienna is, according to Spasky, 1° to 20 metres. The very accurate experiments of Magnus, in 1831 at Rüdersdorf, near Berlin, on the occasion of the boring of an artesian well, yielded the same result, but at Pregny, near Geneva, Messrs. Rieve and Marcet found the depth corresponding to an increase of 1° Cent. to be 32 metres. The well was sunk 220 metres. This figure represents sufficiently exactly the average rate of increase of temperature resulting from thermometric soundings made in artesian wells. Walferdin found an increase of 1° to 31 metres in the artesian wells of the Military School at Paris, in that at St. André (Eure) and in the well of Grenelle; and many others have given figures comprised between 30 and 35 metres for the difference of level representing a difference of 1° in temperature. The temperature of the water of the Grenelle well, 548 metres deep, and of the Passy well, 570 metres deep, is 28°, while the mean temperature of Paris is 10·6. These waters, therefore, receive from the deep strata an addition to their temperature of a little more than 17°; i. e., a little more than 1° to each 32 metres of depth. The much deeper borings of Musalweek, near Minden in Prussia, 700 metres, and of Mondorf in the grand duchy of Luxemburg, 730 metres, show a difference of 1° to 30 or 31 metres.

From a comparison of the temperatures observed by Walferdin near Creuzot, at the bottom of a boring 816 metres deep, and in a neighboring well 554 metres deep, it also appears that at these depths the heat increases more rapidly than at the surface. But wells situated very near each other may give widely varying results. Thus at Naples, according to M. Mallet, in two very deep artesian wells, distant from each other 1,600 metres, the depths corresponding to 1° of additional heat were 45 and 109 metres respectively.

The observations of M. Mohr, in 1876, in a well 4,000 feet deep, pierced through a salt-rock at Speremberg, near Berlin, led this physicist to believe that the rate of progression sensibly slackens as we descend below the surface—a conclusion agreeing with Fox's deductions from observations in the English coal-mines. M. Mohr remarked that from 700 feet, where the glass marked 19·6° Cent., to 3,300 feet, where it marked 46°, the difference in temperature corresponding to a difference of 100 feet, diminished in a regular ratio, so that, continuing the sounding, beyond 5,000 feet only a barely perceptible increase could be observed. But M. A. Boué, who warmly contested M. Mohr's conclusions, has observed with reason that percolated water will frequently lower the temperature of these deep beds, and this would explain the diminution observed by M. Mohr.

In this class of researches thermometers *à déversement* are used, the reservoirs of which overflow as the temperature rises; the mercury remaining in the ball shows the maximum attained. Walferdin's registering thermometer and the geothermometer of Magnus are constructed on this principle. Thermometers *à minima*, of a different construction, are used to determine the temperature of the ocean-depths, which are generally colder than the water at the surface. The many soundings made by the English scientific expeditions established beyond a doubt the fact that the temperature at the bottom of the sea is often but little above zero. This would be explained by supposing the colder water to be carried to the bottom by its specific gravity, the water warmed and dilated by the sun's heat remaining at the surface. The bed of the ocean at large, where the normal temperature is not affected by warm currents, such as the Gulf Stream, may be said to be covered with water at the freezing-point. The water at the bottom of fresh-water lakes is less cold because the maximum density of fresh water is 4°. It results from this that the portions possessing this temperature are carried to the bottom, while the colder or warmer portions rise to the surface. Thus, that portion of the earth's shell that is covered by water remains at a relatively low temperature, in consequence of the stratification resulting from the varying densities of the liquid, but, if it were possible to carry on in the bed of the sea such investigations as have been made on land, an increase of temperature, such as has been proved to exist in the frozen soil of Siberia, would doubtless be found.

The increase in heat as we descend is generally admitted to average 1° in 30 metres. If this rate is constant it is clear that, at a depth of 2,700 metres, the temperature must equal that of boiling water; and that, at a depth of 50 kilometres, the heat must exceed 1,600°, a point at which iron and the greater part of the rocks would melt. This is the principal ground for the argument of those who maintain that the earth's crust is not more than 40 to 50 kilometres thick—or, relatively to its size, of the thickness of an egg-shell compared with the egg. Certain it is that the increase of heat with the depth, confirmed by so many observers, perforce gives a warrant to the idea of a subterranean fire possessing an inconceivable degree of heat; but the question is, At what depth from the surface does this fire exist?

The thermometric observations thus far made are insufficient to decide this question. Among the mines that have reached a great depth may be mentioned those of Kitzbühel in the Tyrol (900 metres); Kutteuberg in Bohemia (1,200 metres); Mouille-Louge (920 metres); and Speremberg (1,260 metres). Why may not borings be made at the bottom of some of these very deep mines, by means of which the bowels of the earth can be still further penetrated?

It is also desirable that the natural cavities in the earth should be utilized for scientific investigation. The accounts contained in the old books that relate to this matter are unfortunately filled with exaggerations, and the lack of recent evidence prevents our extracting from them the portion of truth they perhaps contain. Pontoppidan, in his "Natural History of Norway," describes a cavity in the vicinity of Frederickshall, in which the duration of the fall of a stone appeared to be two minutes. Assuming, says Arago, that the stone fell clear, without hitting and being retarded by projections in the walls of the cavity, the total depth indicated by its two minutes' fall would be over 4,000 metres, exceeding by 800 metres the height of the highest mountain in the Pyrenees. But it would appear that the noise of the stone's falling was heard for two minutes—that it consequently rolled and bounded from point to point; and modern travelers have nothing further to say of the famous Frederickshall hole. Another account, of the legendary cavern of Dolsteen, in the Island of Herroe, Norway, is likewise doubtful. According to a belief among the inhabitants, this cavern extended to and under Scotland. It is told that, in 1750, two priests ventured far into it and heard the rumbling of the sea above them. Coming to the brink of a precipice, they threw over a large stone, which was heard to fall a minute after. Without, however, attaching importance to accounts from such unreliable sources, it may still be admitted that natural cavities exist which might be made use of in exploring the deeper strata of the earth's crust. M. Babinet, who cherished the idea of forming a society for digging a deep hole for such purposes, thought the question had its industrial side which ought not to be lost sight of. "This is no longer," he somewhere says, "the time of Voltaire, who so bitterly berated Maupertuis, whom he described as having wished to pierce the earth that we might see our antipodes by leaning over the edge of the well of this antagonist of the irascible king of literature. Nobody would to-day deny the possibility of sinking the shafts of mines to a depth of several thousand metres, when we have such choice of ground, dimensions, and, above all, time. Let us suppose that we have reached a depth of four kilometres only, and cleared a suitable space. If men can not support the heat, machines, which are not so delicate, can. We see ourselves in possession of a vast space, the walls of which are of the temperatures of our ovens and stoves. Conducting thereto a stream of water, it issues hotter than boiling water, and is a veritable mine of heat, as truly so as are the precious coal-mines of England and Belgium." It is a fact that the heat of the springs of Chaudes-Aigues, which reaches 80°, is made use of by the inhabitants for purposes of cooking, heating their houses, washing, etc. By conduits of wood, in all the streets of the village, reservoirs on the ground-floor of each house are supplied, and these serve the purpose of heating-stoves in cold weather, fires and chimneys being dispensed with. In summer, the inflow is stopped by little sluice-gates at the inlet of each supply-pipe, the water then flowing to the brook at the border of the village. M. Berthier, the chemist, has estimated that the heat furnished daily by these springs equals that produced by the combustion of more than four and a half tons of coal, sufficient to comfortably warm the houses and even the streets.*

Now that the rapid exhaustion of coal-mines forces man to seek the precious combustible at increasingly greater depths, it interests us to know the extreme limit of accessible depth. The report of the English commission of inquiry contains very complete data on this point.† The sole cause, says the report, that can place a limit on the practicable depth of mines is the elevation of temperature. In the English mines the temperature is of marked uniformity to the depth of about 15 metres, viz., 10° Cent. From that depth the heat increases at the rate of 1° to 37 metres, so that at a kilometre of depth it attains blood-heat. This heat hinders the mining operations by heating the air that is artificially made to circulate in the mines, and rendering its effect insignificant. Regarding the question of the highest temperature man can work under without danger to health, the evidence gathered by the commission exhibits some extraordinary cases, but such of them as were verified were found to be exaggerated. Competent authorities are, however, united in maintaining that steady labor is impossible, in humid air, at a temperature approaching 37°. Heat is better supported in dry air. Now, as the deepest mines are generally the least humid, we ought, with the powerful means of ventilation available in these days, to certainly reach a depth of 1,200 metres. We may perhaps go even deeper, thanks to the system of atmospheric shafts recently introduced at Epinac by a French engineer, M. Z. Blanchet. By means of a pneumatic tube the cars are propelled and a thorough ventilation is secured at the same time. By developing this system, very deep deposits can doubtless be reached.

[*To be continued.*]

CHANGES OF THE CIRCULATION DURING CEREBRAL ACTIVITY.

By CHARLES SEDGWICK MINOT, S. B., S. D.

DR. ANGELO MOSSO, the distinguished Professor of Physiology at the University of Turin, has made some observations on the physiology of the brain which, for novelty and interest, have been equaled by but few recent scientific discoveries ; for his researches lie

* Elisée Reclus, "La Terre," vol. i, p. 239.

† See in the "Revue" for October 1, 1876, an article on the "Coal Production of England and France."

in the debatable land between physiology and psychology, and have contributed to the advance of both sciences.

The history of these discoveries illustrates in a very striking manner the unexpected developments to which scientific research sometimes leads. In 1873–'74 Dr. Mosso experimented in the laboratory of Professor Ludwig, at Leipsic, upon the circulation of the blood through the kidney. He took advantage of the fact that death is a double process: 1. The death of the animal as a whole, or that which we ordinarily call death; and, 2. The subsequent and gradual death of the tissues, to which is due the curious phenomenon that an organ survives the animal of which it has formed a part. The most remarkable and familiar instance of this is the heart of the frog or turtle, which may continue to beat, for several days even, after the animal to which it belonged has been killed. So also the vitality of the kidney may be preserved by proper precautions for a considerable period. The organ *overlives*, as it is expressed in German. To physiologists this overliving of tissues is of the utmost value, because it enables them to perform numerous experiments that would otherwise be difficult or impossible, which latter alternative would have been the case with Mosso's researches upon the renal circulation.

Mosso's experiments were briefly as follows: Their connection with the subject of this article will appear directly. The kidney was taken from a dog immediately after his death, and glass tubes inserted into the artery and the vein, so that blood could be passed through the former into the kidney, under any desired pressure, sufficient to force it through the vessels of the organ into the vein, whence it could pass out by the glass tube, and be collected in a receptacle. It is unnecessary to describe the details of the experiments—the ingenious devices adopted to prevent the drying up of the kidneys, or irregularities of the pressure of the blood; in short, to eliminate those conditions which might disturb the accuracy of the results. Let it suffice to say that the kidney after its removal from the body was found to preserve its vitality to a fuller extent than had been previously supposed. The especial result of Mosso's experiments was the demonstration of the alterations of the circulation which take place in a single organ independently of the central nervous system, from which the kidney was of course entirely severed. It was noted among other things that the capacity of the blood-vessels altered: under one set of circumstances the kidney held more, under another less blood. This could be detected in two ways: first, when the capacity increased, more blood would enter the artery than flowed out from the vein, or, if the capacity diminished, more would flow out than in; and, second, by changes in the volume of the kidney. The latter method was the most valuable, because the changes in the volume could be actually measured. This was accomplished by placing the kidney in a glass case filled with oil. The tubes for the artery and the vein passed out through the side of the case.

Through a third hole passed a horizontal glass tube. Now, when the kidney increased in volume it drove the oil into the horizontal glass tube, when it contracted the oil was sucked back again—hence by measuring the distance the oil advanced or retreated, the corresponding increase or diminution of size of the kidney could be exactly determined.

The physiological importance of the changes of the volume of a single organ was thus clearly established. If it was possible to record those changes in an isolated organ, why not try to record them of a part, a limb still connected with the body? The possibility conceived was soon accomplished. The apparatus was altered and improved. In its new form it could be used to record the changes in the volume of the human forearm by tracing them upon a piece of paper in the shape of a series of curves.

The construction of the apparatus, as finally adopted by Mosso, is shown in the accompanying woodcut, copied from the original memoir* of its inventor, who calls his instrument a *plethysmograph* (*pletismografo*), because it writes the filling (*plethusmo*) and unfilling of an object.

The apparatus consists of—

1. A glass cylinder, A B, forty-eight centimetres long and eight or ten in diameter, open at one end, and terminating in a small neck at the other. It is furnished with two openings, C and D, which serve to fill it with water and to introduce a thermometer. These openings may be closed with corks. The arm of the person to be experimented upon is introduced into this cylinder.

2. A broad ring at A of vulcanized rubber to fit around the end of the cylinder and around the arm introduced into it, so as to form a water-tight joint.

3. A board, E, suspended from above, and serving to support the glass vessel, with the included arm.

4. The recording instruments. These have a difficult office to perform, for they must register the changes in the volume of the limb. The forearm is placed in the cylinder A B, which is then filled with water; when the arm swells, the water is driven out through the rubber tube F; when the arm shrinks, the water is sucked back. Now, it is the amount of water expelled or drawn in which is to be measured—this is accomplished by the following means: The rubber tube F opens into a glass tube G, which, bending at right angles, descends to the level *a b* of the liquid contained in the large beaker P. The descending limb is perfectly vertical, and securely fixed in that position by being fastened to an iron support. A thin-walled test-tube, M, about eighteen centimetres long, is suspended by two silk threads from the double wheel L, and balanced by a counter weight N, which also car-

* "Sopra un nuovo Metodo per scrivere i Movimenti dei Vasi Sanguini nell' Uomo." "Atti della Reale Accademia delle Scienze di Torino," vol. xi (November 14, 1875).

ries a kymographic pen, suitable for drawing a line upon a sheet of paper drawn past the point of the pen by a clock-work constructed for that purpose.

The test-tube M is so hung that its axis is traversed by the vertical descending limb of the glass tube G, and the test-tube can move up or down without striking the tube occupying its center.

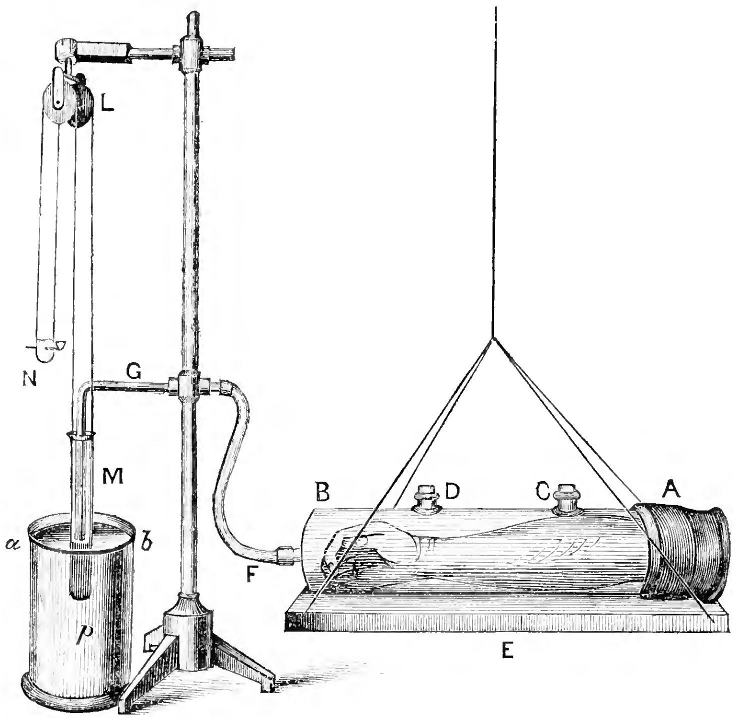


FIG. 1.—MOSSO'S PLETHYSMOGRAPH.

If, now, the glass cylinder containing the arm and the tubes F and G are filled with water, and the arm begins to expand, then the water will be forced out into the test-tube M, which will therefore descend into the fluid in the beaker, P, raising, as it descends, the counter-weight and pen, N. If, on the contrary, the arm contracts, the water will be sucked back, the test-tube M will be lighter, the counter-weight will pull it back, and the pen will descend. Let us suppose that the point of the pen rests against a sheet of paper which is being drawn along horizontally with a constant velocity. As long as the pen is stationary it will draw a horizontal line ; if it ascends, it will draw an ascending curve ; when it falls, a descending curve. Such a line is technically termed a tracing. It shows the extent and duration of the motion, and exemplifies one of the many applications of the graphic method. The horizontal distances, since they are determined by the rate at which the paper moves, correspond to the time. For example, if the paper moves an inch per minute, then, if we measure up a horizontal line the number of inches along which the tracing continues to rise, we can fix the points corresponding to a given time, and measure the height to which the pen had risen at any given instant, and also the rate at which it rose.

The vertical motion of the pen depends on the rise and fall of the test-tube M, which in its turn is caused by the out- and in-flow of the water surrounding the arm. Hence, a rise in the curve corresponds to an expansion, a fall to a contraction of the forearm. There are other details and precautions in the construction and use of the apparatus requisite to secure entire accuracy, for which I must refer to the original memoir. Modifications of the apparatus have been made by Ludwig and Kronecker, and a very essential improvement has been suggested and used by Dr. H. P. Bowditch, of Boston. These improvements are important to the experimenter, but have only a subsidiary interest for the general reader. The plethysmograph can be employed for many purposes. For example, it may serve as a very perfect thermometer, by applying it to record the changes of a closed volume of air, which of course increases or diminishes according as the temperature rises or falls.

With the aid of the plethysmograph Mosso discovered that the activity of the brain is directly connected with the circulation of the forearm. The importance of this fact will be better understood, if it is considered that we here have a physical phenomenon we can accurately measure, directly connected with mental phenomena we can not measure.

It is well known that the functional activity of an organ of the human body is accompanied by increased activity of the circulation, and this is also true of the brain. Since the total amount of blood is not subject to rapid and sudden changes, it is evident that, when an active part receives more blood, other parts must receive less. When the brain is at work, blood is withdrawn from the arm, which therefore becomes smaller.

In order that the volume of the forearm should remain constant, absolute tranquillity is necessary ; the slightest movement of the mind suffices to disturb the equilibrium of the vascular system. The plethysmograph is an instrument with which we can record even emotions not depicted by any expression of the countenance, or revealed only by unnoticeable changes in the beating of the heart or of the respiratory movements. "Therefore," says Mosso, "I think it my duty to commence with a tracing that represents the sentiment of veneration which I felt in the presence of my beloved master. Behold, in fact, the contraction of the vessels produced by the entrance of Professor Ludwig, every time he honored the researches made upon myself with a visit." I have translated as literally as possible Mosso's words—those unfamiliar with Italian should remember that words like "veneration" and "master," when rendered literally, convey a more fervid feeling in English than is expressed by the original. We reproduce the tracing referred to; the upper line is drawn by the pen, and its descent corresponds to the diminution of the volume of Mosso's right forearm; A marks the point when Professor Ludwig entered. The lower line records the time, each notch corresponding to an interval of five seconds. The diminution of volume was equal to about six

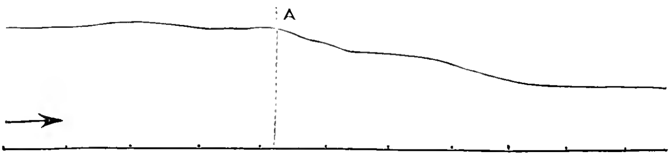


Fig. 2.—Curve traced by the Plethysmograph, showing the diminution of size in the forearm, produced by the emotions caused by Ludwig's entrance at A.

cubic centimetres. This effect was not due to any strong emotion of fear or anxiety, but merely to the affectionate respect which Professor Ludwig's genial manners win from his pupils. The same experiment was tried upon Dr. Pagliani, with the same result.

Cerebral activity, like all the emotions, is reflected by the vascular system. To test this, the person experimented upon was given some simple arithmetical problem to solve; this was chosen because it could be solved without the person's speaking, which would have necessitated a change in the respiration, and so have modified the circulation. Fig. 3 shows the effect of calculating 245×15. The lines as before. This experiment was made upon Dr. Frey, and testifies to the great effect of a comparatively light and brief mental labor. It appeared that the

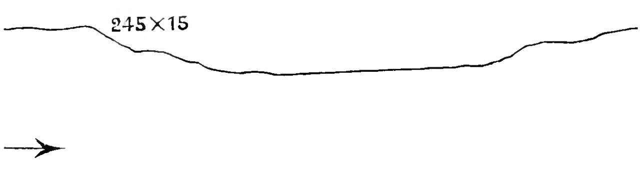


Fig. 3.—Curve traced by the Plethysmograph, showing the diminution of size in the forearm of Dr. Frey, produced by his calculating 245×15.

more complicated the sum to be solved the longer and greater was the contraction of the arm. The response of the circulation is very ready and marked, and, in persons of excitable temperaments, strong effects are produced from such very slight causes that it is sometimes difficult to make any experiments upon them.

There is undoubtedly a relation between the intensity of the emotion or mental process and the change in the circulation. This is illustrated in the following curious experiment upon one of Mosso's friends, who was a student of literature: While his arm was in the apparatus, Mosso presented to him a few pages on which were pasted paragraphs in Greek and Italian indiscriminately. By watching the changes in the volume of the arm, Mosso was able to decide correctly when his friend was reading a Greek paragraph, because to the greater mental effort corresponded a greater contraction of the vessels.

But the amount of blood in the extremities varies not only with psychical but also with physiological activities—for instance, with the respiration. The size of the forearm was shown by the plethysmograph to diminish during a deep inspiration, to increase during a prolonged and powerful expiration; or, again, alterations may be called forth by irritation of the skin of the arm, or even of a distant part of the body, or by direct compression of such of the veins or arteries of the upper arm as do not lie too deep to be reached, or even by changing the position of a limb other than the one being experimented upon. In brief, an almost endless variety of circumstances affect the circulation of a given part, as shown by the changes of its volume; but, among these circumstances, the condition of the brain is especially influential.

Mosso, however, has not confined his investigations to the waking condition, but has extended them also to men asleep, thus discovering a very great increase in the volume of the forearm as a person gradually falls asleep. The large size of the forearm during sleep may be diminished by a dream, or by any cause that renders the sleep less profound. It was evident that persons hear in their sleep various sounds, which disturb their slumbers but do not wake them up. When his friend was asleep, Mosso saw him move as a dog near by barked, and at the same time the apparatus recorded a diminution in the size of the extremity. Observation in this case shows that the cerebral activity during sleep is much greater than is usually supposed, and that a person may dream, as is evident by his moving or making some sound, yet have no recollection of it upon awaking. The plethysmograph preserves a more accurate record, for the slightest movement or disturbance produces its effect upon the arm, diminishing its volume. As a person awakes naturally, the size of the forearm is gradually lessened, because the blood is withdrawn.

To summarize the result: whenever the brain acts in any way, blood is withdrawn from the arm and from all the extremities; when the brain is inactive, more blood circulates in the limbs, most during sleep.

By the same apparatus, Mosso also discovered that the circulation was changed by a dose of chloral very nearly, if not exactly, as in natural sleep; and that this drug, tested by these phenomena, produced a slumber very similar to normal sleep.

Pursuing his researches in other directions, Professor Mosso has succeeded in demonstrating that, when the brain acts, not only does the arm receive less blood, but the brain actually does receive more. This result was, of course, to be anticipated; and in making this further observation Mosso is not the first, for other physiologists have published researches upon this point, only less accurate and complete than those of the distinguished Italian investigator.

Opportunities for observing the circulation of the human brain are very rare, and occur only in consequence of violent accidents or insidious diseases, causing a loss of a piece of the bony skull sufficient to leave the soft brain exposed. Through such an opening it can be observed that the soft brain is smaller during sleep than during waking, because during the former state it draws back from the opening, and during the latter it may swell so much as even to protrude through the opening. That these changes are not abnormal results due to the diseased condition, is shown by the experiments which have been made upon healthy dogs by artificially removing a small piece of the skull, which can be done without causing any serious injury. In animals thus operated upon, the same changes of volume can be seen to occur in the brain, and closer observation shows that the variations are due to contraction or expansion of the blood-vessels.

These investigations demonstrate that one of the physiological conditions of increased mental action is an increased supply of blood, which is produced principally by a dilatation of the cerebral blood-vessels, accompanied by a contraction of the blood-vessels of other parts of the body. The measurable volume of the arm is thus partly a signal of the condition of the mind we can not measure, as affirmed in the early part of this article.

In connection with the new tendencies of psychology and physiology, such investigations as we have just described acquire a peculiar significance. The progress of knowledge has so enlarged the domains of both psychology and physiology, that they now overlap. The fields of investigation held in common form the bourn of "physiological psychology," as it is termed by the Germans, who are ever ready with a new name. Now, the mind derives its material through the senses. The sensations arise from physical causes. The final results of mental performances are various actions of the body, physical events such as motion and speech. Physics, therefore, are the alpha and omega of our mental history. Concerning what occurs between the physical cause of sensation and the physical result of mental action, two extreme opinions stand opposed. On the one hand, mind is defined as a succession of purely physical phenomena; on the other, as a supernatural and immortal power.

Hitherto psychologists have usually studied very little besides what we might call the natural history of the mind. Just as the ornithologist may study the habits of a bird, its mode of hopping, flying, feeding, singing, and so forth, and make himself thoroughly familiar with its natural history, without learning anything of its anatomy, the laws of muscular contraction or digestion, so also the philosopher may investigate the actions of the mind, the succession and relations of ideas, or may formulate the principles of logic, in entire ignorance of the processes which occur in the brain. The conclusions in both cases may be perfectly accurate, but they do not concern the more hidden and less accessible factors.

It is important to recognize the relation of psychology to the physiology of the brain, and to relegate both to their proper places. In reality they are only the different sides of one study—and the best distinction of psychology is its success in arranging and classifying the psychic phenomena, whose relation to the physical basis of mind is to be determined. Although psychology is usually regarded as a department of philosophy, it is certainly more completely a natural science, since it deals with natural events, which are learned by direct observation, and which we coördinate by our reason. The slow but unmistakable gravitation of psychology toward physiology does not forecast, it seems to me, the demise of the former, but indicates rather that psychologists, having now gathered and arranged a great mass of data concerning the mind, are making an inevitable step in progress in seeking deeper than ever before for explanations. During the new phase, into which psychology has apparently entered, the principal problems will probably concern the relation of mind to the substratum of matter in which it displays itself. The most important steps which we can hope to take at present must, as far as we can judge, be taken in the field of physiological psychology, the essential purpose of which is to discover the exact nature of the dependence of the psychic phenomena on the physiological and anatomical properties of the body. It is precisely in this direction that Professor Mosso has made an important advance.

Mind appears to us as an image, dimly seen through the clouds of physical facts which encompass it. Some assert it to be merely a mirage, or, at most, an accidental shape into which physical facts have compiled themselves. Others believe that mind is a thing of its own kind. When the sunlight of discovery shall dispel the mists of the unknown, that conceal the true nature of the mind, then that image, now so dim, will become distinct, and its real character evident. That such a result is attainable is the belief, without which many laborious investigations would become purposeless.

GOETHE'S FARBENLEHRE.—(THEORY OF COLORS.*)

By Professor JOHN TYNDALL, F. R. S.

II.

ONE hole Goethe did find in Newton's armor, through which he incessantly worried the Englishman with his lance. Newton had committed himself to the doctrine that refraction without color was impossible. He therefore thought that the object-glasses of telescopes must for ever remain imperfect, achromatism and refraction being incompatible. This inference was proved by Dollond to be wrong.† With the same mean refraction, flint-glass produces a longer and richer spectrum than crown-glass. By diminishing the refracting angle of the flint-glass prism, its spectrum may be made equal in length to that of the crown-glass. Causing two such prisms to refract in opposite directions, the colors may be neutralized, while a considerable residue of refraction continues in favor of the crown. Similar combinations are possible in the case of lenses ; and hence, as Dollond showed, the possibility of producing a compound achromatic lens. Here, as elsewhere, Goethe proves himself master of the experimental conditions. It is the power of interpretation that he lacks. He flaunts this error regarding achromatism incessantly in the face of Newton and his followers. But the error, which was a real one, leaves Newton's theory of colors perfectly unimpaired.

Newton's account of his first experiment with the prism is for ever memorable. "To perform my late promise to you," he writes to Oldenburg, "I shall without further ceremony acquaint you that in the year 1666 (at which time I applied myself to the grinding of optick-glasses of other figures than spherical) I procured me a triangular glass prism, to try therewith the celebrated phenomena of colors. And in order thereto, having darkened my chamber, and made a small hole in my window-shuts, to let in a convenient quantity of the sun's light, I placed my prism at its entrance, that it might be thereby refracted to the opposite wall. It was at first a very pleasing divertisement, to view the vivid and intense colors produced thereby ; but after a while applying myself to consider them more circumspectly, I became surprised to see them in an oblong form, which, according to the received laws of refractions, I expected should have been circular. They were terminated at the sides with straight lines, but at the ends the decay of light was so gradual that it was difficult to determine justly what was their figure, yet they seemed semicircular.

* A discourse delivered in the Royal Institution of Great Britain, on Friday evening, March 19, 1880.

† Dollond was the son of a Huguenot. Up to 1752 he was a silk-weaver at Spitalfields ; he afterward became an optician.

"Comparing the length of this colored *spectrum* with its breadth, I found it about five times greater; a disproportion so extravagant that it excited me to a more than ordinary curiosity of examining from whence it might proceed." This curiosity Newton gratified by instituting a series of experimental questions, the answers to which left no doubt upon his mind that the elongation of his spectrum was due to the fact "that *light* is not similar or homogeneal, but consists of *difform rays, some of which are more refrangible than others;* so that, without any difference in their incidence on the same medium, some shall be more *refracted* than others; and therefore that, according to their *particular degrees of refrangibility,* they were transmitted through the prism to divers parts of the opposite wall. When," continues Newton, "I understood this, I left off my aforesaid glass-works; for I saw that the perfection of telescopes was hitherto limited, not so much for want of glasses truly figured according to the prescriptions of optick authors, as because that *light* itself is an heterogeneous mixture of *differently refrangible rays;* so that were a glass so exactly figured as to collect any one sort of rays into one point, it could not collect those also into the same point, which, having the same incidence upon the same medium, are apt to suffer a different refraction."

Goethe harped on this string without cessation. "The Newtonian doctrine," he says, "was really dead the moment achromatism was discovered. Gifted men, our own Klügel, for example, felt this, but expressed themselves in an undecided way. On the other hand, the school which had been long accustomed to support, patch up, and glue their intellects to the views of Newton, had surgeons at hand to embalm the corpse, so that even after death, in the manner of the Egyptians, it should preside at the banquets of the natural philosophers."

In dealing with the chromatic aberration of lenses, Goethe proves himself to be less heedful than usual as an experimenter. With the clearest perception of principles, Newton had taken two pieces of cardboard, the one colored a deep red, the other a deep blue. Around those cards he had wound fine black silk, so that the silk formed a series of separate fine dark lines upon the two colored surfaces. He might have drawn black lines over the red and blue, but the silk lines were finer than any that he could draw. Illuminating both surfaces, he placed a lens so as to cast an image of the surfaces upon a white screen. The result was that, when the dark lines were sharply defined upon the red, they were undefined upon the blue; and that, when, by moving the screen, they were rendered distinct upon the blue, they were indistinct upon the red. A distance of an inch and a half separated the focus of red rays from the focus of blue rays, the latter being nearer to the lens than the former. Goethe appears to have attempted a repetition of this experiment; at all events he flatly contradicts Newton, ascribing his result not to the testimony of his bodily eyes, but to that of the prejudiced eyes of his mind. Goethe always saw the dark lines best defined upon the brighter color. It was to him purely a matter of contrast, and not of different refrangibility. He argues caustically that Newton proves too much; for, were he correct, not only would a dioptric telescope be impossible, but, presented to our naked eyes, differently colored objects must appear utterly confusing. Let a house, he says, be supposed to stand in full sunshine; let the roof-tiles be red, the walls yellow, with blue curtains behind the open windows, while a lady with a violet dress steps out of the door. Let us look at the whole from a point in front of the house. The tiles we will suppose appear distinct, but on turning to the lady we should find both the form and the folds of her dress undefined. We must move forward to see her distinctly, and then the red tiles would appear nebulous. And so with regard to the other objects, we must move to and fro in order to see them clearly if Newton's pretended second experiment were correct. Goethe seems to have forgotten that the human eye is not a rigid lens, and that it is able to adjust itself promptly and without difficulty to differences of distance enormously greater than that due to the different refrangibility of the differently colored rays.

Newton's theory of colors, it may be remarked, is really less a "theory" than a direct presentation of facts. Given the accepted definition of refraction, it is a matter of fact, and not of theoretic inference, that white light is not "homogeneal," but composed of differently refrangible rays. The demonstration is ocular and complete. Having palpably decomposed the white light into its constituent colors, Newton recompounded these colors to white light. Both the analysis and the synthesis are matters of fact. The so-called "theory of light and colors" is in this respect very different from the corpuscular theory of light. Newton's explanation of color stands where it is, whether we accept the corpuscular or the undulatory theory; and it stands because it is at bottom not a theory but a body of fact, to which theory must bow or disappear. Newton himself pointed out that his views of colors were entirely independent of his belief in the "corporiety" of light.

After refraction-colors Goethe turns to those produced by diffraction; and, as far as the phenomena are concerned, he deals very exhaustively with the colors of thin plates. He studies the colors of Newton's rings both by reflected and transmitted light. He states the conditions under which this class of colors is produced, and illustrates the conditions by special cases. He presses together flat surfaces of glass, observes the flaws in crystals and in ice, refers to the iridescences of oil on water, to those of soap-bubbles, and to the varying colors of tempered steel. He is always rich in facts. But, when he comes to deal with physical theory, the poverty and confusion of his otherwise transcendent mind become conspicuous. His turbid media entangle him everywhere, leading him captive and committing him to almost incredible delusions. The colors of tempered steel, he says, and kindred phenomena, may perhaps be *quite conveniently deduced* from the action of turbid media. Polished steel powerfully reflects light, and the coloring produced by heating may be regarded as a feeble turbidity, which, acted upon by the polished surface behind, produces a bright yellow. As the turbidity augments, this color becomes dense, until finally it exhibits an intense ruby-red. Supposing this color to reach its greatest proximity to darkness, the turbidity continuing to augment as before, we shall have behind the turbid medium a dark background, which appears first violet, then dark blue, and finally light blue, thus completing the cycle of the phenomena. The mind that could offer such an explanation as this must be qualitatively different from that of the natural philosopher.

The words "quite conveniently deduced," which I have italicized in the last paragraph, are also used by Goethe in another place. When the results of his experiments on prismatic colors had to be condensed into one commanding inference, he enunciated it thus: "Und so lassen sich die Farben bei Gelegenheit der Refraction aus der Lehre von den trüben Mitteln gar bequem ableiten." This is the crown of his edifice, and it seems a feeble ending to so much preparation. Kingsley once suggested to Lewes that Goethe might have had a vague feeling that his conclusions were not sound, and that he felt the jealousy incident to imperfect conviction. The ring of conscious demonstration, as it is understood by the man of science, is hardly to be found in the words "gar bequem ableiten." They fall flaccid upon the ear in comparison with the mind-compelling Q. E. D. of Newton.

Throughout the first 350 pages of his work, wherein he develops and expounds his own theory, Goethe restrains himself with due dignity. Here and there, there is a rumble of discontent against Newton, but there is no sustained ill-temper or denunciation. After, however, having unfolded his own views, he comes to what he calls the "unmasking of the theory of Newton." Here Goethe deliberately forsakes the path of calm, objective research, and delivers himself over to the guidance of his emotions. He immediately accuses Newton of misusing, as an advocate, his method of exposition. He goes over the propositions in Newton's "Optics" one by one, and makes even the individual words of the propositions the objects of criticism. He passes on to Newton's experimental proofs, invoking, as he does so, the complete attention of his readers, if they would be freed to all eternity from the slavery of a doctrine which has imposed upon the world for a hundred years. It might be thought that Goethe had given himself but little trouble to understand the theorems of Newton and the experiments on which they were based. But it would be unjust to charge the poet with any want of diligence in this respect. He repeated Newton's experiments, and in almost every case obtained his results. But he complained of their incompleteness and lack of logical force. What appears to us as the very perfection of Newton's art, and absolutely essential to the purity of the experiments, was regarded by Goethe as needless complication and mere torturing of the light. He spared no pains in making himself master of Newton's data, but he lacked the power of penetrating either their particular significance, or of estimating the force and value of experimental evidence generally.

He will not, he says, shock his readers at the outset by the utterance of a paradox, but he can not withhold the assertion that by experiment nothing can really be proved. Phenomena may be observed and classified; experiments may be accurately executed, and made thus to represent a certain circle of human knowledge; but deductions must be drawn by every man for himself. Opinions of things belong to the individual, and we know only too well that conviction does not depend upon insight, but upon will—that man can only assimilate that which is in accordance with his nature, and to which he can yield assent. In knowledge, as in action, says Goethe, prejudice decides all, and prejudice, as its name indicates, is judgment prior to investigation. It is an affirmation or a negation of what corresponds, or is opposed to our own nature. It is the cheerful activity of our living being in its pursuit of truth or of falsehood, as the case may be —of all, in short, with which we feel ourselves to be in harmony.

There can be no doubt that Goethe, in thus philosophizing, dipped his bucket into the well of profound self-knowledge. He was obviously stung to the quick by the neglect of the physicists. He had been the idol of the world, and, accustomed as he was to the incense of praise, he felt sorely that any class of men should treat what he thought important with indifference or contempt. He had, it must be admitted, some ground for skepticism as to the rectitude of scientific judgments, seeing that his researches on morphology met at first no response, though they were afterward lauded by scientific men. His anger against Newton incorporates itself in sharp and bitter sarcasm. Through the whole of Newton's experiments, he says, there runs a display of pedantic accuracy, but how the matter really stands, with Newton's gift of observation, and with his experimental aptitudes, every man possessing eyes and senses may make himself aware. It may, he says, be boldly asked, Where can the man be found, possessing the extraordinary gifts of Newton, who would suffer himself to be deluded by such a *hocus pocus* if he had not in the first instance willfully deceived himself? Only those who know the strength of self-deception, and the extent to which it sometimes trenches on dishonesty, are in a condition to explain the conduct of Newton, and of Newton's school. "To support his unnatural theory," he continues, "Newton heaps experiment on experiment, fiction upon fiction, seeking to dazzle where he can not convince."

It may be that Goethe is correct in affirming that the will and prejudice of the individual are all-influential. We must, however, add the qualifying words, "as far as the individual is concerned." For in science there exists, apart from the individual, objective truth ; and the fate of Goethe's own theory, though commended to us by so great a name, illustrates how, in the progress of humanity, the individual, if he err, is left stranded and forgotten—truth, independent of the individual, being more and more grafted on to that tree of knowledge which is the property of the human race.

The imagined ruin of Newton's theory did not satisfy Goethe's desire for completeness. He would explore the ground of Newton's error, and show how it was that one so highly gifted could employ his gifts for the enunciation and diffusion of such unmitigated nonsense. It was impossible to solve the riddle on purely intellectual grounds. Scientific enigmas, he says, are often only capable of ethical solution, and with this maxim in his mind he applies himself, in the second volume of the "Farbenlehre," to the examination of "Newton's Persönlichkeit." He seeks to connect him with, or rather to detach him from, the general character of the English nation—that sturdy and competent race which prizes above all things the freedom of individual action. Newton was born in a storm-tossed time—none, indeed, more pregnant in the history of the world. He was a year old when Charles I. was beheaded, and he lived to see the First George upon the throne. The shock of parties was in his ears, changes of ministries, parliaments, and armies were occurring before his eyes while the throne itself, instead of passing on by inheritance, was taken possession of by a stranger. What, asks Goethe, are we to think of a man who could put aside the claims, seductions, and passions incident to such a time, for the purpose of tranquilly following out his bias as an investigator?

So singular a character arrests the poet's attention. He had laid down his theory of colors ; he must add to it a theory of Newton. The great German is here at home, and Newton could probably no more have gone into these disquisitions regarding character than Goethe could have developed the physical theories of Newton. He prefaces his sketch of his rival's character by reflections and considerations regarding character in general. Every living thing, down to the worm that wriggles when trod upon, has a character of its own. In this sense even the weak and cowardly have characters, for they will give up the honor and fame which most men prize highest, so that they may vegetate in safety and comfort. But the word character is usually applied to the case of an individual with great qualities, who pursues his object undeviatingly, and without permitting either difficulty or danger to deflect him from his course.

"Although here, as in other cases," says Goethe, "it is the exuberant (Ueberschwängliche) that impresses the imagination, it must not be imagined that this attribute has anything to do with moral feeling.

The main foundation of the moral law is a *good* will,* which, in accordance with its own nature, is anxious only for the right. The main foundation of character is a *strong* will, without reference to right or wrong, good or bad, truth or error. It is that quality which every party prizes in its members. A good will cherishes freedom, it has reference to the inner man and to ethical aims. The strong will belongs to nature and has reference to the outer world—to action. And, inasmuch as the strong will in this world is swayed and limited by the conditions of life, it may almost be assumed as certain that it is only by accident that the exercise of a strong will and of moral rectitude find themselves in harmony with each other." In determining Newton's position in the series of human characters, Goethe helps himself to images borrowed from the physical cohesion of matter. Thus, he says, we have strong, firm, compact, elastic, flexible, rigid or obstinate, and viscous characters. Newton's character he places under the head of rigid or obstinate, and his theory of colors Goethe pronounces to be a petrified *aperçu*.

Newton's assertion of his theory and his unwavering adherence to it to the end of his life Goethe ascribes straight off to moral obliquity on Newton's part. In the heat of our discussion, he says, we have even ascribed to him a certain dishonesty. Man, he says, is subject to error, but when errors form a series, which is followed pertinaciously, the erring individual becomes false to himself and to others. Nevertheless, reason and conscience will not yield their rights. We may belie them, but they are not deceived. It is not too much to say that, the more moral and rational a man is, the greater will be his tendency to lie when he falls into error, and the vaster will be that error when he makes up his mind to persist in it.

This is all intended to throw light upon Newton, but, when Goethe passes from Newton himself to his followers, the small amount of reserve which he exhibited when dealing with the master entirely disappears. He mocks their blunders as having not even the merit of originality. He heaps scorn on Newton's imitators. The expression of even a truth, he says, loses grace in repetition, while the repetition of a blunder is impertinent and ridiculous. To liberate one's self from an error is difficult, sometimes indeed impossible for even the strongest and most gifted minds. But to take up the error of another, and persist in it with stiff-necked obstinacy, is a proof of poor qualities. The obstinacy of a man of originality when he errs may make us angry, but the stupidity of the copyist irritates and renders us miserable. And, if in our strife with Newton we have sometimes passed the bounds of moderation, the whole blame is to be laid upon the school of which Newton was the head, whose incompetence is proportional to its arrogance, whose laziness is proportional to its self-sufficiency, and

* I have rendered Goethe's "gute Wille" by *good* will; his "Wollen," which he contrasts with "Wille," I have rendered by *strong* will.

whose virulence and love of persecution hold each other in perfect equilibrium.

There is a great deal more invective of this kind; but you will probably, and not without sadness, consider this enough. Invective may be a sharp weapon, but over-use blunts its edge. Even when the denunciation is just and true, it is an error of art to indulge in it too long. We not only incur the risk of becoming vapid, but of actually inverting the force of reprobation which we seek to rouse, and of bringing it back by recoil upon ourselves. At suitable intervals, separated from each other by periods of dignified reserve, invective may become a real power of the tongue or pen. But indulged in constantly it degenerates into scolding, and then, instead of being regarded as a proof of strength, it is accepted, even in the case of a Goethe, as an evidence of weakness and lack of self-control.

If it were possible to receive upon a mirror Goethe's ethical image of Newton and to reflect it back upon its author, then, as regards vehement persistence in wrong thinking, the image would accurately coincide with Goethe himself. It may be said that we can only solve the character of another by the observation of our own. This is true; but in the portraiture of character we are not at liberty to mix together subject and object as Goethe mixed himself with Newton. So much for the purely ethical picture. On the scientific side something more is to be said. I do not know whether psychologists have sufficiently taken into account that, as regards intellectual endowment, vast wealth may coexist with extreme poverty. I do not mean to give utterance here to the truism that the field of culture is so large that the most gifted can master only a portion of it. This would be the case supposing the individual at starting to be, as regards natural capacity and potentiality, rounded like a sphere. Something more radical is here referred to. There are individuals who at starting are not spheres, but hemispheres; or, at least, spheres with a segment sliced away—full-orbed on one side, but flat upon the other. Such incompleteness of the mental organization no education can repair. Now, the field of science is sufficiently large, and its studies sufficiently varied, to bring to light in the same individual antitheses of endowment like that here indicated.

So far as science is a work of ordering and classification, so far as it consists in the discovery of analogies and resemblances which escape the common eye—of the fundamental identity which often exists among apparently diverse and unrelated things—so far, in short, as it is observational, descriptive, and imaginative, Goethe, had he chosen to make his culture exclusively scientific, might have been without a master, perhaps even without a rival. The instincts and capacities of the poet lend themselves freely to the natural history sciences. But, when we have to deal with stringently physical and mechanical conceptions, such instincts and capacities are out of place. It was in this region of mechanical conceptions that Goethe failed. It was on this side that his sphere of capacity was sliced away. He probably was not the only great man who possessed a spirit thus antithetically mixed. Aristotle himself was a mighty classifier, but not a stringent physical reasoner. And, had Newton attempted to produce a "Faust," the poverty of his intellect on the poetic and dramatic side might have been rendered equally manifest. But here, if not always, Newton abstained from attempting that for which he had no capacity, while the exuberance of Goethe's nature caused him to undertake a task for which he had neither ordination nor vocation, and in the attempted execution of which his deficiencies became revealed.

One task among many—one defeat amid a hundred triumphs. But any recognition on my part of Goethe's achievements in other realms of intellectual action would, I fear, be regarded as impertinent. You remember the story of the First Napoleon when the Austrian plenipotentiary, in arranging a treaty of peace, began by formally recognizing the French Republic. "Efface that," said the First Consul; "the French Republic is like the sun; he is blind who fails to recognize it." And were I to speak of recognizing Goethe's merits, my effacement would be equally well deserved. "Goethe's life," says Carlyle, "if we examine it, is well represented in that emblem of a solar day. Beautifully rose our summer sun, gorgeous in the red, fervid east, scattering the specters and sickly damps, of both of which there were enough to scatter; strong, benignant in his noonday clearness, walking triumphant through the upper realms—and now mark also how he sets! 'So stirbt ein Held'; so dies a hero!"

Two grander illustrations of the aphorism "To err is human" can hardly be pointed out in history than Newton and Goethe. For Newton went astray not only as regards the question of achromatism, but also as regards a vastly larger question touching the nature of light. But though as errors they fall into the same category, the mistake of Newton was qualitatively different from that of Goethe. Newton erred in adopting a wrong mechanical conception in his theory of light, but in doing so he never for a moment quitted the ground of strict scientific method. Goethe erred in seeking to ingraft in his "Farbenlehre" methods altogether foreign to physics on to the treatment of a purely physical theme.

We frequently hear protests made against the cold mechanical mode of dealing with æsthetic phenomena employed by scientific men. The dissection by Newton of the light to which the world owes all its visible beauty and splendor seemed to Goethe a desecration. We find, even in our own day, the endeavor of Helmholtz to arrive at the principles of harmony and discord in music resented as an intrusion of the scientific intellect into a region which ought to be sacred to the human heart. But all this opposition and antagonism has for its essential cause the incompleteness of those with whom it originates. The feelings and aims with which Newton and Goethe respectively approached Nature were radically different, but they had an equal warrant in the constitution of man. As regards our tastes and tendencies, our pleasures and pains, physical and mental, our action and passion, our sorrows, sympathies, and joys, we are the heirs of all the ages that preceded us; and, of the human nature thus handed down, poetry is an element just as much as science. The emotions of man are older than his understanding, and the poet who brightens, purifies, and exalts these emotions, may claim a position in the world at least as high and as well-assured as that of the man of science. They minister to different but to equally permanent needs of human nature; and the incompleteness of which I complain consists in the endeavor on the part of either to exclude the other. There is no fear that the man of science can ever destroy the glory of the lilies of the field; there is no hope that the poet can ever successfully contend against our right to examine, in accordance with scientific method, the agent to which the lily owes its glory. There is no necessary encroachment of the one field upon the other. Nature embraces them both, and man, when he is complete, will exhibit as large a toleration.

MY FIRE.

BY PROFESSOR F. W. CLARKE.

WITHIN my grate a cheerful blaze
Lights up the room with ruddy rays,
That blunt the winter's sharpest stings
With bygone summer's offerings.
I sit and watch the leaping flame,
In wonder whence its beauty came;
And trace it back to days of old,
When Earth's hard crust was scarcely cold,
And tropic trees in arctic zones
Taught the north-wind those subtile tones,
Which, now and then, its weary blast
Seems to regather from the past,
To murmur in a mystic song
The secret-keeping pines among.
And, as I gaze, I somehow see
Strange things that long have ceased to be:
The sooty carbon seems to glow
With memories of long ago,
And in the flickering lines of gold
The story of its past is told.

Ages ago, when Earth was young,
And all her beauties yet unsung—
Save in the songs that Nature weaves
Into the texture of the leaves,
Or teaches to the insect swarms
That fill the light with darting forms—
A meteor, like some silly moth,
To meet destruction nothing loath,
Drawn by a force it could not shun,
Broke from its circles round the Sun,
And in a flashing spiral flight
Shot to the central source of light.
New fuel fed the solar flame;
New sunbeams into being came;
And these, unconscious of their birth,
Sought speedily the whirling Earth.

In that far-off, mysterious day
The undeveloped planet lay
Afloat in space, a different thing
From that which bears us on its wing.
Forgotten rivers downward ran
From mountains never seen by man,
To oceans, long since dried away,
Whose beds are continents to-day.
And overhead the heavens bent
Not wholly like our firmament.
Some stars, perchance, that now are cold,
In their deserted orbits rolled;
And others shone more brightly then
Than since abashed by gaze of men.
The very Sun intenser glowed
As on the heavenly way he strode,
And sent to space the fiercer heat
Of fiery youth and vigor sweet.

Through vapors dense the sunbeams fell,
And worked in passing many a spell
On ancient rocks and flowing streams,
And decked with unaccustomed gleams
The wings of insects proud to be
The wearers of such livery.
Then on through forests where the breeze
Found giant ferns grown into trees,
That in their waving branches held
The wealth of summer undispelled.

Strange flowers turned bright faces up
To catch the light in many a cup,
And all of nature gladly sought
The blessings by the sunbeams wrought.
But these fair rays whose deeds I sing
Staid nowhere long for anything ;
Leaping from rock, and leaf, and tree,
From stream and pool with equal glee,
Until, half buried in the ground,
A freshly fallen seed they found.
And here they halted ; here at last
A welcome duty held them fast.

As day by day the sunbeams fell,
A tiny leaflet burst its shell ;
And soon a stem of tender green
Was thrust above the earthy screen.
Daily it drank the air and dew ;
Daily the sunlight warmed it through ;
Up to a mighty tree it grew.
A tower of fronded foliage high
Above the forest sought the sky ;
Whose sturdy stem, erect, defied
Tempest or flood with haughty pride,
And for a century bravely stood
The monarch of the solitude.

But Time, who conquers all things, saw
This perfect tree without a flaw ;
And sent an insect, weak and small,
To bring about its certain fall.
Gnawed at the root, its strength decayed ;
The forest giant bent and swayed,
And with a shuddering crash it fell
From the high place it loved so well.
Buried in slime, and ooze, and clay,
The perished king forgotten lay.

The Ages, with resistless tread,
Marched slowly on above the dead ;
And where the tree had grandly grown
They piled a thousand feet of stone.
A royal tomb, with royal state,
Was token of the monarch's fate :
Surely the future has for us
No worthier sarcophagus.

At last came Man, with eager brain,
To ransack Earth in search of gain;
And where a brook had cleft apart
The rocks to reach a mountain's heart,
Deep in the chasm he could trace
An ancient forest's burial-place.
In sheets of coal the eye could mark
The very texture of the bark;
And see, with every tender vein
Still sharply outlined, clear and plain,
Leaves that had wooed the morning sun
When Time itself was scarce begun,
And turned to stone the giant stem
That wore the leafy diadem.

Brightly my fire of coal may burn—
Backward my thoughts, resistless, turn.
With keen imagination's eye
I see the Ages passing by:
I see the meteor's headlong flight;
A planet's death; the birth of light;
The ancient world, unlike our own;
The mighty forest turned to stone;
And, scene by scene, before my eyes,
The whole long vanished past arise.
And from my grate I feel the glow
Of sunbeams fallen long ago,
Stored up by Nature's magic art
Within a tree's untainted heart,
To sleep a myriad ages long,
And wake the subject of a song.

A VINDICATION OF SCIENTIFIC ETHICS.*

By WILLIAM D. LE SUEUR, B. A.

MR. SPENCER, in his "Data of Ethics," has not written a popular treatise on morals, nor has he appealed to any lower tribunal than the highest intelligence and the maturest judgment of his generation. The more I think of his book, the more it seems to me a sign that shall be spoken against, but a sign, at the same time, in which, or by which, great victories will be won for the human race.

* This able article first appeared in "The Canadian Monthly," under the title of of "Mr. Spencer and His Critics."

I am far from saying that it tells us everything we might wish to know in regard to the springs of conduct, or the special sources of moral energy; but I contend that it tells us much that is of supreme importance, and that anything we may require to add to the statements it contains will not be found in conflict with the writer's main positions.

Mr. Spencer, it must be understood, undertakes to trace for us the evolution of morality as an objective process. Morality, like everything else, must have a history. What is that history? This is the question to which Mr. Spencer addresses himself. If we can trace the development of morality in the past, we shall be better able to understand its characteristics in the present, and its probable course in the future. Mr. Spencer says truly that morality is a certain aspect of *conduct* in general; it is, as he holds, *developed* conduct; and, in order that we may understand what conduct is, he asks us to examine it in its earliest manifestations, and to follow it through the ages, as it gains in definiteness, in complexity, in range, and in the importance of its reactions upon consciousness. This is a view, the legitimacy of which it seems impossible to dispute. When our attention is arrested by any structure in nature, we very properly ask: "How has it come to be what it is? Did it spring into existence at once, in the form under which we behold it now, or was it shaped by slow degrees? If the latter, what were the stages through which it successively passed?" Do not tell us that the same questions can not profitably be asked in regard to morality until the questions have been fairly put and answered according to the best obtainable knowledge.

The great objection hitherto made to the scientific study of history, or of any moral subject, has been that all calculations based upon general laws of growth or progress are liable at any moment to be thrown into confusion by the appearance upon the scene of forces or of influences of a wholly exceptional character. Thus the birth of some man of transcendent abilities may alter, it is said, the whole course of a nation's history. The answer to this objection is twofold: first, that the great man or hero is himself a product of antecedent conditions, and is born into a society more or less fitted to feel and submit to his influence; secondly, that the effects wrought by exceptional characters are but exceptional, and that the great stream of human development follows its course but little affected by accidents here or there. Mr. Spencer, therefore, and those who think with him, may, without in the least compromising their system, make large admissions as to the influence of certain special agencies. They do not necessarily blind themselves to the course of history in the ordinary sense of the word, because they make a special study of the development of conduct. The line of observation and argument pursued in the "Data of Ethics" is hopelessly antagonistic only to that form of supernaturalism which disbelieves totally in evolution, preferring to regard human history as the theatre of forces having no relation to preceding conditions, and acting consequently as simple disturbers of the natural equilibrium of society. The adherents of this school must only fight the development theory as best they may. The battle is engaged, however, along the whole line, and, to defeat evolution, you must defeat it not in ethics only, but in biology and physics as well. As long as the two latter divisions hold their ground, be sure that any victory over the first can be but momentary.

It is obvious that the method pursued by Mr. Spencer must give rise to many misapprehensions. The first thought that suggests itself to even an attentive and earnest reader is, that he has left out of sight, and is prevented by his principles from doing justice to, a number of very important considerations. Our individual consciousness tells us nothing of the dependence of present modes of conduct upon past; but it tells us much of the special motives which influence us from moment to moment. So a wave of the sea, if we could imagine it conscious, might know much of the pressure of adjacent waves and its own adjustments of form in consequence of that pressure, but might know nothing of ocean-currents or the attraction of sun and moon. We feel the influence of some potent personality, but think little of the causes that have fitted us to do so; yet, to be able to trace and understand those causes, would give us a far more comprehensive theory of our moral nature than to be able to analyze and measure with the utmost accuracy the special personal influence by which we are so strongly affected. In a word, what may be called the accidents of our life fill an altogether larger space in consciousness than the general laws, in virtue of which we are substantially what we are. Mr. Spencer has undertaken to trace those general laws, leaving accidents out of sight as much as possible; and, naturally, consciousness protests. If, however, we only call to mind, and impress upon ourselves, what it is that Mr. Spencer attempts, we shall recall many of our criticisms, and find it better to listen attentively to what he has to say.

Again, with every action there goes a certain accompaniment of individual feeling. We have a sense of its voluntariness, and a consequent sense of responsibility. To us, each action stands and is seen in relation to the sum of our own individual actions, and the proportion which it bears to that sum is very different from the proportion it bears to the whole sum of action in general. It is easy, therefore, to conceive how different the subjective view of action must be from the objective, and how far a history of action such as Mr. Spencer undertakes to write must be from such an account as we might gather from the dicta of consciousness. But, if our individual lives are but links in one great chain of life, which we have learned in these latter days to extend to the lowest forms of the animate creation, can the individual consciousness, however bright and penetrating we may suppose it, be trusted in its affirmations regarding the genesis of action and the development of moral feeling? What can mere consciousness—apart from knowledge derived from external sources—tell us of our bodily constitution and development? It is occupied almost solely with sensations of pleasure and pain; it knows what are proximate causes of one or the other; but what the laws are that rule the human organization it is wholly ignorant. We have absolutely no consciousness of the nature of digestion or respiration; we only know in a rough way what creates disturbances in one region or the other, and what promotes comfort. Is it likely that we shall know any better from a simple questioning of our individual consciousness how our actions are produced, or what is their essential character and true significance? It seems to me that the feelings accompanying moral action are no safer guides to a true understanding of that action than the feelings accompanying digestion are to a true understanding of digestion. The objective method of study, as applied to human conduct, has this great advantage, that, while looking at things from the outside, and grasping the *enchainement* of cause and effect through all past time, it can also take account of the direct revelations of consciousness, so far as these seem to furnish any safe guidance. Mr. Spencer, it may be presumed, knows something personally of the inner life of humanity. He has written this treatise in full view of all that his personal experience has taught him of the motives by which men are swayed, and we must suppose that, in his mind at least, there is no contradiction between his philosophical theories and the teachings of life or the affirmations of consciousness. It is well to bear in mind that philosophers after all are men first and philosophers only afterward.

The adverse criticisms that have been offered upon Mr. Spencer's last work may be said to resolve themselves into two leading objections: first, that he does away with the essential distinction between right and wrong; and, second, that, for regulative purposes, his system is wholly unadapted to human wants. I propose to consider these points separately.

Let us, in the first place, try to understand clearly what Mr. Spencer's view is. Looking at conduct objectively he sees, as we advance from lower to higher forms in nature, an ever-increasing and improving adaptation, first to the preservation of individual life, and next to the preservation of the life of progeny. The lowest creatures in the animal kingdom possess little or no power of self-protection, and are therefore, broadly speaking, wholly at the mercy of their environment. With greater complexity of structure comes greater power of providing for wants and averting dangers; while the interests of the progeny become more and more a care to the parent animals. The time comes, in process of evolution, when the individual acquires the power of choice between opposite courses of action. One sense may prompt to a certain line of action, and another to a different one. Smell, for example, may attract to food, but sight may reveal an enemy of superior power; or certain mental images, which the sight of offered food, or of the apparatus in which it is placed, calls up, may inspire caution and compel abstinence. Mr. Spencer here shows that the interest of the individual is generally concerned in obeying the higher or more lately-developed sense, instinct, or faculty, in preference to the simpler and more primitive impulse; and this distinction between actions inspired by more far-reaching and those inspired by less far-reaching perceptions he considers as homologous to the distinction which emerges in the human region—and which, as civilization advances, becomes ever more pronounced—between right and wrong. In the one case the individual weighs present gratification against his permanent interests as an individual; in the second he weighs his interests as an individual against those of the social body in which he is included. In either case he does well if he yield to the larger thought—that which summons to self-control, and which promises a continuance and enlargement of his activities. From this point of view the conduct which places a man in harmony with society is simply an extension, a further development, of the conduct which places him in harmony with himself, by subordinating his momentary desires to his permanent interests. In the one case he says: "I have a larger life to consider than that of this moment; I have all my past, the memory of which I would not wish to extinguish; I have all my future, which I am not prepared to sacrifice." In the latter he says: "I have a larger life to consider than that which is made up of my personal pains and pleasures; I have inherited sympathies and acquired attachments; the good will of my fellow-man is much to me, and I feel that, apart from the support and assistance that they render me and apart from the activities I exercise as a member of society, I should be a miserably contracted creature. Shall I therefore in the interests of my narrower self make war upon my larger and better self by pursuing anti-social courses of action?" The argument in both cases is the same; the only difference is that in one case length of life is at stake, and in the other breadth of life; but all higher action, it may be assumed as a principle, tends to life. "Do this and ye shall live"; in these words lies all that the evolution philosophy has to teach on the subject of morals; for they summon to right action, and they point to the reward—Life.

I fail to see that under this mode of treatment the distinction between right and wrong is in danger of disappearing. Those possibly who have considered it a pious thing not to know why right is right or why wrong is wrong may resent being told that a *rationale* of the antagonism between the two has been discovered. They may insist that they have hitherto done right and avoided wrong from motives far transcending in elevation any regard for perpetuation or improvement of life, their own or others'; and it would be ungracious, doubtless, to contradict them. But, for all that, as a motive to sway the mass of mankind, the thought that right action tends to life and higher life, that wrong action tends to lower life and ultimately to extinction of life, should scarcely, one would think, be a sterile or inoperative one. Much would depend, no doubt, upon the mode in which the thought was presented by those who have it in their power to influence public opinion. That the minds of a large portion of the community have been so poisoned by the drugs of a false theology as to be incapable of responding to any teaching based on the pure laws of nature there is only too much reason to believe ; but I should refuse to admit as valid against the evolutionist system of morals any argument drawn from their present condition or requirements.

The objections made to Mr. Spencer's explanation of the difference between right and wrong are very similar to those made to the Darwinian theory of the descent of man. In the dispute which raged more violently some years ago than it does now in reference to this question, an angelic character pronounced himself "on the side of the angels," as was but natural. It was thought utterly derogatory to man's dignity to suppose that his ancestry could run back into the brute creation ; and so to-day it seems to threaten the stability of all moral distinctions to connect moral actions, by any process of filiation, with actions which, as we understand morality, present no moral character whatever. But just as no theory of man's origin can make him other than he actually is to-day, so no theory of the origin of morality can affect the fact that in the conscience of the modern civilized man there is a great gulf fixed between right and wrong. But, some will say, upon the evolution theory the highest morality is but self-seeking. Be it so, but if myself embraces other selves, if my personality has globed itself out till it includes a large portion of humanity, I can afford to be self-seeking without any falling away from nobility or disinterestedness. When Jesus said, "He that saveth his life shall lose it, and he that loseth his life shall save it," he meant, as we have always understood, that a careful study and pursuit of narrow personal interests would involve the sacrifice of wider and nobler interests ; and that, on the other hand, by a surrender of our lower selves, we could rise to higher life. From whichever point we view it, he bids us aim at *life*, and so far he might be accused of prompting to self-seeking ; but when we once see how life may be understood, and what it may be made to include, we perceive how pointless is the objection. It is indeed difficult to imagine how any person, except one who had been restrained from evil simply by superstitious fears, could feel himself less bound to do right and avoid wrong because he had been shown that right actions to-day are the lineal descendants of all those actions, conscious and unconscious, by which life has been preserved, and improved in the past, and that wrong actions claim their paternity in whatever in the past has tended to disintegration, degradation, and death. Who would not rather be on the side of the forces of life, in harmony with and aiding the upward movement of nature, than helping to tear down the good work that the toiling ages have wrought?

Can such a system, however, possess any binding force? Here we find ourselves face to face with the question, whether the evolutionist theory of morals is really adapted to take the place of those regulative systems which Mr. Spencer represents as ready to pass away. One thing is certain: it does not act upon the mind in the same way as systems which appeal to supernatural terrors and hold out a prospect of supernatural rewards. It will not awaken as powerful emotions as theology has in the past awakened; for theology has connected with theologically-right action rewards wholly incommensurate with the merit of such action, and with theologically-wrong action punishments equally incommensurate with its demerit; while the natural theory of morals can only point to the natural results of actions and promote, as best it can, a disposition to respect natural laws. No doubt this is tame work after what we have been accustomed to; but everything grows tame, in a sense, as civilization advances. We no longer torture criminals, nor feast our piety with *autos-da-fe*. We no longer thrash knowledge into school-children; and we are so dead to the necessity of cultivating national spirit that we forbid prize-fighting. Upon every hand, the drastic methods of the past are discredited, for we find, in point of fact, that gentler methods are better. Sangrado no longer depletes our veins of the blood needed for carrying on the processes of life; we keep our blood and let Nature have her way as much as possible. No doubt there is further progress to be made in the same direction; and who shall say that a system of rational rewards and punishments in *this* life, such as the evolution philosophy unfolds, may not be found more efficacious than the monstrous rewards and punishments of the supernatural sphere. Such a system may not inspire death-bed terrors, but neither will it provoke life-long jeerings; and, if once understood theoretically, its gentle—though not always gentle—pressure would rarely be absent from consciousness. The villain, it may be said, will think little of sacrificing his higher social to his lower personal self; and, in his case, therefore, the system would be inoperative. Precisely, and how does Monsieur the villain comport himself now? Does he occupy a front seat at church (something here whispers that sometimes he does, but that is another kind of villain, and there is no use in mixing up matters), and send his children to Sunday-school, and show in every way the great influence which theological instruction has had upon his mind? Or we may ask whether, in the "ages of faith," the villain was an unknown character? History tells us that, when supernatural hopes and fears—above all fears, which are more potent than hopes—were at their highest, precisely then was there most of violence and crime. And, when natural morality finally succeeds to supernatural, it is safe to predict that it will find some heavy arrears of work on hand.

We need not trouble ourselves, then, with considering how the lowest types of humanity will act under the supposed *régime;* what we are concerned with is the effect likely to be produced upon the mass of society. As regards men in general, will natural morality exert a sufficient regulative force? To this question I should be inclined to answer unhesitatingly yes, provided only proper means be taken to bring the new system home to people's understandings. No one will pretend that the theology now in possession exerts all the regulative influence that could be desired. For one thing, it can not make itself believed by large multitudes; and, in the second place, very many of those who do believe it, or who profess to do so, are far from leading edifying lives. Every leading religious denomination has numerous representatives in our jails and penitentiaries, as official documents show; while, if we turn to the records of the insolvency courts, we shall find ample evidence that men can be at once zealous supporters of a church and sadly inexact—to say the least—in money matters. Why do I mention these things? Surely not to cause any one pain, but simply to show how the question stands. Some people argue as if we had *now* a perfect regulative system, which the new opinions are in danger of disturbing. But no; we have a very imperfect regulative system, upon which it is hoped a great improvement may be made. Theologians have, for some time past, been sensible of the shortcomings of the old teaching, for they have been trying to graft upon it the idea of the *naturalness* of the rewards and punishments to be meted out to right- and wrong-doers respectively. We hear now that sinners will not be overtaken by any external penalties, but will be left to the simple and inevitable consequences of their own misconduct. They would not be happy, we are told, in heaven, because their characters are not adapted to that abode of bliss; and, upon the whole, therefore, they are better off on the other side of the great gulf. How all this can be reconciled with the teaching of the Bible, where hell is represented, not as prepared by the sinner for himself, but as prepared by God for the devil and his angels, and heaven, in like manner, as something specially prepared for the righteous, who there enjoy a felicity with which the sufferings of this present time are not worthy to be compared, it is not for me to say. One thing is clear, however, and that is, that such glosses as these are recognitions of and concessions to the principle of development. Heaven, according to this hypothesis, is the developed life of righteousness, and hell the developed life of moral rebellion; but, though theology may dally with this view, it can never do more than dally with it; it can never make it its own, seeing that the text of the Bible so plainly declares the cataclysmal nature of the change which takes place at death. But, if theology has to dally with development, how much better founded, and how much better adapted for acting upon men's minds, must a system be which, from first to last, assumes development, and which is not checked in its exposition and application of natural laws by any stereotyped creed or text?

In the new system we really have the reconciliation of self-interest and duty, for we see self-interest merging into duty, and we see duty bringing the highest rewards that self-interest could desire. To say that this system will be powerless for regulative purposes is to take a thoroughly unnatural view of human nature. It is to assume some tendency in man to evil, over and above the promptings of the self-protective instinct. Now, this surplusage of evil in human nature I, for one, strenuously deny. Every man comes into the world with a problem to solve, upon the solution of which his whole course in life depends; and that problem is the due balancing of higher and lower instincts in the interest of higher life. To suppress the lower at the bidding of the higher would, as Mr. Spencer shows, be to suppress life itself. This would be casting aside the problem, not solving it. What is important to remember is, that in the lower there is nothing essentially bad, and that the conflict between lower and higher goes on in the region of purely personal desires before it is carried into the region of social relations. An enlightened interpretation of self-interest in regard to personal matters is thus a preparation for enlightened and worthy action in the social region. For example, the man who has strenuously controlled appetite in the interest of health, and who has realized the satisfaction and happiness that come of doing so, will be better fitted to control selfish, in the interest of social, impulses than one who had never learned to control appetite at all. He comes to this higher test fortified by self-conquest, and with an increased sense of the dignity and worth of life—prepared, moreover, to believe that the path of true happiness is an ascending one. Let these truths—for they *are* truths—be believed and taught; let men see the path along which their moral development has lain in the past, and along which it must lie in the future, and we shall have little reason to regret the lures and terrors of the old theology. Either this, or there is some radical flaw in the constitution of things, by reason of which they tend to corruption—a belief which some may hold on theological grounds, but which I venture to say would never commend itself to any unbiased intelligence, irreconcilable, as it is, with the actual existence of good in human nature and human institutions.

The question, however, may finally be asked whether a naturalistic system of morals will ever excite the enthusiasm, ever create the same intense longing after purity of heart, that has been produced under the influence of the Christian creed. Will it ever show us the "quick-eyed sanctity" which Dr. Newman mentions as a peculiar fruit of the Spirit? Will it ever call forth such a pleading for fuller and higher spiritual life as we find in Charles Wesley's hymn:

"I want a principle within
Of jealous, godly fear,
A sensibility to sin,
A pain to feel it near.

"I want the first approach to feel
Of pride or fond desire,
To catch the wandering of my will,
And quench the kindling fire.

"Quick as the apple of an eye,
O God, my conscience make!
Awake my soul when sin is nigh,
And keep it still awake."

We have in these verses the expression of a passionate desire for conformity to a divine ideal, and the question is, whether we can expect any approach to the same earnestness in pursuit of such excellence or elevation of character as the evolution philosophy indicates as attainable. If allowance be made for the solemnity imparted to the above utterance by the momentous character of Christian beliefs, I see no reason why the moral enthusiasm of humanity should not flow in as full tide through the new channel as through the old. After all, there are but few in every generation who are fired by an intense desire for the highest holiness; and some, it must be remembered, who appear to have very lofty spiritual ambitions, give occasion for the remark that they might better have aimed at humbler achievements. We may, therefore, reasonably hope that, when once it is understood where the hopes of humanity lie, there will be no falling off, to say the least, in the number of those who will strive after nothing short of the highest ideal their minds are capable of conceiving.

In conclusion, let us see what answer can be given to certain specific objections that have been made by able writers to Mr. Spencer's theories on this subject. "The Bystander" thinks that Mr. Spencer's indignation "against Jingoes and their political burglaries; against Fifeshire militiamen who, so long as they are sent to war, are ready to fight on either side; against Christian bishops who lend their sanction to invasion of Afghanistan," is, upon his own principles, unscientific; inasmuch as all these might retort that their actions were the natural product of their particular stage of development. To this I reply that Mr. Spencer's indignation is the measure of his own moral development, and signifies his instinctive recoil from courses of conduct which show the moral sense in a very backward state. Even when we understand how bad actions have come to be performed, and are prepared to make allowances for the perpetrators, we shrink from and denounce them none the less. We surely should allow the philosophers some common human privileges. As to the supposed answer of the burglarious Jingo, the unprejudiced militiaman, and the filibustering bishop, it is in substance, though not in form, the answer commonly made to moral remonstrance by people who can not understand the grounds of the remonstrance. It matters not whether you come in the name of a scientific morality or of a traditional theology, the man who "will have none of your reproofs" replies promptly, "I see no harm in it." Talk to him of God: he has, *comme tout le monde*, one of his own, who permits that wherein he indulges; and you will have much work to persuade him that your God is of higher authority than his. It will be as tough a task as explaining to him a chapter of "The Data of Ethics."

Professor Calderwood, writing in the January number of the "Contemporary Review," raises the objection that, whereas it is admitted by Mr. Spencer that the words *good* and *bad* are most emphatically applied to those deeds by which men affect one another, this ought not to be so, upon Mr. Spencer's own principles: on the contrary, "no ethical judgments should be so direct, unhesitating, or emphatic as those which pronounce upon the actions contributing to personal satisfaction." The answer to this is simple enough. The historical antecedents or the remote types of moral actions are not themselves necessarily moral. Purposive action in the lower animals is not moral, though it may be said to be a preparation for morality. We pronounce our most emphatic judgments upon those acts by which men affect one another, because in them we see most conspicuously the conflict of higher and lower impulses, and because members of society must have an especial interest in what men do as *members of society*. Every right action done adds to the security and happiness of life, every wrong action implies some diminution of happiness, and seems to threaten the general welfare. The whole of morality is based upon the fact that "there is a lower and a higher"; and wherever the two come plainly into conflict our feelings are more or less strongly engaged. Thus, if we see a man struggling with intemperance and enduring keen suffering in the attempt to conquer the vice, we commend him—even though he may have no wife and children to excite our interest—as much as if we saw him performing, at great cost to himself, an act of social justice. And why? Because we feel so deeply that the struggle is one in the interest of higher, fuller life and happiness.

Professor Calderwood appears to think that he raises a serious difficulty when he asks, "How comes it to pass that actions most commonly and most emphatically commended are actions which most need to be enforced?" I observe that a recent critic* of Professor Calderwood's work on "The Relations of Mind and Brain," while giving the author credit for general intelligence, says that upon occasions he is positively "obtuse." I should certainly be inclined to say that he was in one of his "obtuse" moods when he put the above question. We commend certain actions more than others because the motives that

* London "Spectator," March 6, 1880.

prompt them are higher, because they imply a more distinct step in moral evolution, because the interest of the community is more concerned in their performance. Now, the Professor wants to know why such actions "most need to be enforced." The first thing to say in answer is that such actions are not commonly "enforced" at all. The acts we praise most highly are acts of patriotism, of eminent public spirit, of devotion to duty under trying circumstances. The acts we "enforce" are acts which, when done, we do not so highly praise, such as simple fulfillment of contract, and the performance of ordinary civic duties. It is possible, however, that Professor Calderwood, when he uses the word "enforced," does not mean legal enforcement, but merely the pressure of public opinion. His question would then be in substance, How is it that the actions which we most commend are those which most need to be commended? But he might as well ask how it is that the actions we most *condemn* are those which most need to be condemned; why the actions we laugh at are those that especially call for ridicule; and so on, through a whole series of ineptitudes. Why certain actions are especially praised I have explained above, and it is manifest, from the nature of the actions referred to, that this social approval must powerfully reënforce the motives which prompt to such actions, but which, without social support, might not have vigor enough to fully assert themselves against countervailing motives. It is impossible, in fact, to understand why the praise is given without understanding at the same time why it is needed.

Again, Professor Calderwood can not understand how, on utilitarian principles, which he regards Mr. Spencer as adopting, *intention* should make so much difference in actions. "Two men might lose their lives by the hands of two of their fellows, and we should call the one a case of murder and the other a case of accidental death." Why—if actions are to be judged solely by their consequences? This is almost too puerile; but, since a Professor of Moral Philosophy at Edinburgh has raised the question, let me simply remark that, while the act of carelessness has no *ulterior* consequences, the act of felony has—or will have if left unpunished—the direst consequences to society. Further, in so far as an act of carelessness is felt to menace society as being likely to lead, if unchecked, to further carelessness, *we do view the matter seriously*, and visit it both with punishment and reprobation. The shipmaster who, through carelessness, loses his ship, has his certificate canceled or suspended. The engine-driver or conductor, through whose carelessness life is sacrificed, finds himself a criminal in the eye of the law. There is this difference, however, between the worst act of carelessness and an act of malignity, that, in the first case, the doer of the act generally suffers more or less in its consequences, and is therefore in a measure punished already; while the willful offender does not feel the wrong he has done, and consequently throws upon society the whole burden of his punishment.

Dr. McCosh, in the "Princeton Review" (November, 1879), touches, perhaps, a weak point in Mr. Spencer's book when he quotes from the chapter on "Absolute and Relative Ethics" the statement that "conduct which has any concomitant of pain, or any painful consequence, is partially wrong." I think we may fairly question Mr. Spencer's right to take the word "wrong" and divorce it so violently from its universally understood meaning as he does in this passage. If he had said that no action can be a *perfect action* "which has any concomitant of pain or any painful consequence," the statement might have passed with the explanation he gives. But to speak of an action which is *the very best that can be done under given circumstances* as "partially wrong," is to strain language unduly. How can it be partially wrong—to cite Dr. McCosh's examples—to submit to an amputation in order to preserve life, or to conquer a vice by painful effort?

Dr. McCosh is probably right, also, in holding that the teaching of the chapter on "Absolute and Relative Ethics" is of somewhat questionable tendency, as leaving altogether too much room for what he calls "the crooked casuistry of the heart." Mr. Spencer's essential meaning I hold to be right; but I hardly think that, considering the novelty of his views, he has been sufficiently guarded in his use of language. He might have said, without in any way betraying his fundamental principles: "The distinction between right and wrong is one that emerges in the region of human, and particularly of social, life; though right and wrong actions, considered as respectively making for or against the preservation and improvement of life, have their analogues in regions lower than the human. A *perfect* action is one all the consequences and relations of which are satisfactory, as tending to happiness or life; and, therefore, no action which has any accompaniment of pain—though the motive of the doer may be of the highest—can be a perfect action. The motive is pure and good, but it has a setting of painful circumstances, and the action as a whole belongs to an imperfect system of life. In practical life we have often to choose between evils, but he who does not choose for the best, when he sees it, violates the highest law of existence." The gist of Mr. Spencer's teaching, in so far as it assumes a moral character, might, I think, be summed up in these words. Taking the book as a whole, and looking, as we are bound to do, at its inner sense, it must, I think, be acknowledged that, while it does not deal with motives or the subjective aspect of morality, the view which it presents of the connections of moral action, the width of its survey over nature, the conclusive manner in which it demonstrates the healthfulness of what is right and the rightness of what is healthful, should tend to confirm in right determinations even those who miss from it what they deem of most importance. To those, on the other hand, who have long been wistfully looking for an exposition of the natural laws and sanctions of morality, it will be a word spoken with power, and in many ways a help toward higher life. There is but little scandal, after all, if we come to think of it, in supposing that action which we call moral may be a developed form of action to which the name can not be applied; but there is great edification in the thought, now brought home to our understandings, that, by every truly moral act, we help to build up and improve the life of the world and make ourselves co-workers with the principle of life everywhere.

THE COMING OF AGE OF THE ORIGIN OF SPECIES.*

By Professor T. H. HUXLEY.

MANY of you will be familiar with the aspect of this small, green-covered book. It is a copy of the first edition of the "Origin of Species," and bears the date of its production—the 1st of October, 1859. Only a few months, therefore, are needed to complete the full tale of twenty-one years since its birthday.

Those whose memories carry them back to this time will remember that the infant was remarkably lively, and that a great number of excellent persons mistook its manifestations of a vigorous individuality for mere naughtiness; in fact, there was a very pretty turmoil about its cradle. My recollections of the period are particularly vivid; for, having conceived a tender affection for a child of what appeared to me to be such remarkable promise, I acted for some time in the capacity of a sort of under-nurse, and thus came in for my share of the storms which threatened even the very life of the young creature. For some years it was undoubtedly warm work, but, considering how exceedingly unpleasant the apparition of the new-comer must have been to those who did not fall in love with him at first sight, I think it is to the credit of our age that the war was not fiercer, and that the more bitter and unscrupulous forms of opposition died away as soon as they did.

I speak of this period as of something past and gone, possessing merely an historical, I had almost said an antiquarian interest. For, during the second decade of the existence of the "Origin of Species," opposition, though by no means dead, assumed a different aspect. On the part of all those who had any reason to respect themselves, it assumed a thoroughly respectful character. By this time the dullest began to perceive that the child was not likely to perish of any congenital weakness or infantile disorder, but was growing into a stalwart personage, upon whom mere goody scoldings and threatenings with the birch-rod were quite thrown away.

In fact, those who have watched the progress of science within the last ten years will bear me out to the full when I assert that there is no field of biological inquiry in which the influence of the "Origin of

* A lecture delivered at the Royal Institution, Friday, March 19, 1880.

Species" is not traceable; the foremost men of science in every country are either avowed champions of its leading doctrines, or at any rate abstain from opposing them; a host of young and ardent investigators seek for and find inspiration and guidance in Mr. Darwin's great work; and the general doctrine of evolution, to one side of which it gives expression, finds in the phenomena of biology a firm base of operations whence it may conduct its conquest of the whole realm of nature.

History warns us, however, that it is the customary fate of new truths to begin as heresies and to end as superstitions; and, as matters now stand, it is hardly rash to anticipate that, in another twenty years, the new generation, educated under the influences of the present day, will be in danger of accepting the main doctrines of the "Origin of Species" with as little reflection, and it may be with as little justification, as so many of our contemporaries, twenty years ago, rejected them.

Against any such a consummation let us all devoutly pray; for the scientific spirit is of more value than its products, and irrationally-held truths may be more harmful than reasoned errors. Now, the essence of the scientific spirit is criticism. It tells us that, to whatever doctrine claiming our assent, we should reply, Take it if you can compel it. The struggle for existence holds as much in the intellectual as in the physical world. A theory is a species of thinking, and its right to exist is coextensive with its power of resisting extinction by its rivals.

From this point of view it appears to me that it would be but a poor way of celebrating the Coming of Age of the Origin of Species were I merely to dwell upon the facts, undoubted and remarkable as they are, of its far-reaching influence and of the great following of ardent disciples who are occupied in spreading and developing its doctrines. Mere insanities and inanities have before now swollen to portentous size in the course of twenty years. Let us rather ask this prodigious change in opinion to justify itself; let us inquire whether anything has happened since 1859 which will explain, on rational grounds, why so many are worshiping that which they burned, and burning that which they worshiped. It is only in this way that we shall acquire the means of judging whether the movement we have witnessed is a mere eddy of fashion, or truly one with the irreversible current of intellectual progress, and, like it, safe from retrogressive reaction.

Every belief is the product of two factors: the first is the state of the mind to which the evidence in favor of that belief is presented; and the second is the logical cogency of the evidence itself. In both these respects the history of biological science during the last twenty years appears to me to afford an ample explanation of the change which has taken place; and a brief consideration of the salient events of that history will enable us to understand why, if the "Origin of Species" appeared now, it would meet with a very different reception from that which greeted it in 1859.

One-and-twenty years ago, in spite of the work commenced by Hutton and continued with rare skill and patience by Lyell, the dominant view of the past history of the earth was catastrophic. Great and sudden physical revolutions, wholesale creations and extinctions of living beings, were the ordinary machinery of the geological epic brought into fashion by the misapplied genius of Cuvier. It was gravely maintained and taught that the end of every geological epoch was signalized by a cataclysm, by which every living being on the globe was swept away, to be replaced by a brand-new creation when the world returned to quiescence. A scheme of Nature which appeared to be modeled on the likeness of a succession of rubbers of whist, at the end of each of which the players upset the table and called for a new pack, did not seem to shock anybody.

I may be wrong, but I doubt if at the present time there is a single responsible representative of these opinions left. The progress of scientific geology has elevated the fundamental principle of uniformitarianism, that the explanation of the past is to be sought in the study of the present, into the position of an axiom; and the wild speculations of the catastrophists, to which we all listened with respect a quarter of a century ago, would hardly find a single patient hearer at the present day. No physical geologist now dreams of seeking outside the ranges of known natural causes for the explanation of anything that happened millions of years ago, any more than he would be guilty of the like absurdity in regard to current events.

The effect of this change of opinion upon biological speculation is obvious. For, if there have been no periodical general physical catastrophes, what brought about the assumed general extinctions and recreations of life which are the corresponding biological catastrophes? And if no such interruptions of the ordinary course of nature have taken place in the organic, any more than in the inorganic, world, what alternative is there to the admission of evolution?

The doctrine of evolution in biology is the necessary result of the logical application of the principles of uniformitarianism to the phenomena of life. Darwin is the natural successor of Hutton and Lyell, and the "Origin of Species" the natural sequence of the "Principles of Geology."

The fundamental doctrine of the "Origin of Species," as of all forms of the theory of evolution applied to biology, is "that the innumerable species, genera, and families of organic beings with which the world is peopled, have all descended, each within its own class or group, from common parents, and have all been modified in the course of descent.*

* "Origin of Species," first edition, p. 457.

And, in view of the facts of geology, it follows that all living animals and plants "are the lineal descendants of those which lived long before the Silurian epoch."*

It is an obvious consequence of this theory of Descent with Modification, as it is sometimes called, that all plants and animals, however different they may now be, must, at one time or other, have been connected by direct or indirect intermediate gradations, and that the appearance of isolation presented by various groups of organic beings must be unreal.

No part of Mr. Darwin's work ran more directly counter to the prepossessions of naturalists twenty years ago than this. And such prepossessions were very excusable, for there was undoubtedly a great deal to be said, at that time, in favor of the fixity of species and of the existence of great breaks, which there was no obvious or probable means of filling up, between various groups of organic beings.

For various reasons, scientific and unscientific, much had been made of the hiatus between man and the rest of the higher mammalia, and it is no wonder that issue was first joined on this part of the controversy. I have no wish to revive past and happily forgotten controversies, but I must state the simple fact that the distinctions in cerebral and other characters, which were so hotly affirmed to separate man from all other animals in 1860, have all been demonstrated to be non-existent, and that the contrary doctrine is now universally accepted and taught.

But there were other cases in which the wide structural gaps asserted to exist between one group of animals and another were by no means fictitious; and, when such structural breaks were real Mr. Darwin could account for them only by supposing that the intermediate forms which once existed had become extinct. In a remarkable passage he says: "We may thus account even for the distinctness of whole classes from each other—for instance, of birds from all vertebrate animals—by the belief that many animal forms of life have been utterly lost, through which the early progenitors of birds were formerly connected with the early progenitors of the other vertebrate classes."†

Adverse criticism made merry over such suggestions as these. Of course it was easy to get out of the difficulty by supposing extinction; but, where was the slightest evidence that such intermediate forms between birds and reptiles as the hypothesis required ever existed? And then probably followed a tirade upon this terrible forsaking of the paths of "Baconian induction."

But the progress of knowledge has justified Mr. Darwin to an extent which could hardly have been anticipated. In 1862 the specimen of *Archæopteryx*, which until the last two or three years has remained unique, was discovered; and it is an animal which, in its feathers and the greater part of its organization, is a veritable bird, while, in other parts, it is as distinctly reptilian.

* "Origin of Species," first edition, p. 458.

† Ibid., p. 431.

In 1868 I had the honor of bringing under your notice, in this theatre, the results of investigations made, up to that time, into the anatomical characters of certain ancient reptiles, which showed the nature of the modifications in virtue of which the type of the quadrupedal reptile passed into that of the bipedal bird; and abundant confirmatory evidence of the justice of the conclusions which I then laid before you has since come to light.

In 1875 the discovery of the toothed birds of the cretaceous formation in North America, by Professor Marsh, completed the series of transitional forms between birds and reptiles, and removed Mr. Darwin's proposition, that "many animal forms of life have been utterly lost, through which the early progenitors of birds were formerly connected with the early progenitors of the other vertebrate classes," from the region of hypothesis to that of demonstrable fact.

In 1859 there appeared to be a very sharp and clear hiatus between vertebrated and invertebrated animals, not only in their structure, but what was more important, in their development. I do not think that we even yet know the precise links of connection between the two; but the investigations of Kowalewsky and others upon the development of *Amphioxus* and of the *Tunicata* prove beyond a doubt that the differences which were supposed to constitute a barrier between the two are non-existent. There is no longer any difficulty in understanding how the vertebrate type may have arisen from the invertebrate, though the full proof of the manner in which the transition was actually effected may still be lacking.

Again, in 1859 there appeared to be a no less sharp separation between the two great groups of flowering and flowerless plants. It is only subsequently that the series of remarkable investigations inaugurated by Hofmeister has brought to light the extraordinary and altogether unexpected modifications of the reproductive apparatus in the *Lycopodiaceæ*, the *Rhizocarpeæ*, and the *Gymnospermeæ*, by which the ferns and the mosses are gradually connected with the Phanerogamic division of the vegetable world.

So, again, it is only since 1859 that we have acquired that wealth of knowledge of the lowest forms of life which demonstrates the futility of any attempt to separate the lowest plants from the lowest animals, and shows that the two kingdoms of living nature have a common border-land which belongs to both or to neither.

Thus it will be observed that the whole tendency of biological investigation since 1859 has been in the direction of removing the difficulties which the apparent breaks in the series created at that time; and the recognition of gradation is the first step toward the acceptance of evolution.

As another great factor in bringing about the change of opinion which has taken place among naturalists, I count the astonishing progress which has been made in the study of embryology. Twenty years ago, not only were we devoid of any accurate knowledge of the mode of development of many groups of animals and plants, but the methods of investigation were rude and imperfect. At the present time there is no important group of organic beings the development of which has not been carefully studied, and the modern methods of hardening and section-making enable the embryologist to determine the nature of the process in each case, with a degree of minuteness and accuracy which is truly astonishing to those whose memories carry them back to the beginnings of modern histology. And the results of these embryological investigations are in complete harmony with the requirements of the doctrine of evolution. The first beginnings of all the higher forms of animal life are similar, and, however diverse their adult conditions, they start from a common foundation. Moreover, the process of development of the animal or the plant from its primary egg or germ is a true process of evolution—a progress from almost formless to more or less highly organized matter, in virtue of the properties inherent in that matter.

To those who are familiar with the process of development all *a priori* objections to the doctrine of biological evolution appear childish. Any one who has watched the gradual formation of a complicated animal from the protoplasmic mass which constitutes the essential element of a frog's or a hen's egg has had under his eyes sufficient evidence that a similar evolution of the animal world from the like foundation is, at any rate, possible.

Yet another product of investigation has largely contributed to the removal of the objections to the doctrine of evolution current in 1859. It is the proof afforded by successive discoveries that Mr. Darwin did not over-estimate the imperfection of the geological record. No more striking illustration of this is needed than a comparison of our knowledge of the mammalian fauna of the Tertiary epoch in 1859 with its present condition. M. Gaudry's researches on the fossils of Pikermi were published in 1868, those of Messrs. Leidy, Marsh, and Cope on the fossils of the Western Territories of America have appeared almost wholly since 1870; those of M. Filhol, on the phosphorites of Quercy, in 1878. The general effect of these investigations has been to introduce us to a multitude of extinct animals, the existence of which was previously hardly suspected; just as if zoölogists were to become acquainted with a country, hitherto unknown, as rich in novel forms of life as Brazil or South Africa once was to Europeans. Indeed, the fossil fauna of the Western Territories of America bids fair to exceed in interest and importance all other known Tertiary deposits put together; and yet, with the exception of the case of the American tertiaries, these investigations have extended over very limited areas, and at Pikermi were confined to an extremely small space.

Such appear to me to be the chief events in the history of the progress of knowledge, during the last twenty years, which account for the changed feeling with which the doctrine of evolution is at present regarded by those who have followed the advance of biological science in respect of those problems which bear indirectly upon that doctrine.

But all this remains mere secondary evidence. It may remove dissent, but it does not compel assent. Primary and direct evidence in favor of evolution can be furnished only by paleontology. The geological record, so soon as it approaches completeness, must, when properly questioned, yield either an affirmative or a negative answer; if evolution has taken place, there will its mark be left; if it has not taken place, there will lie its refutation.

What was the state of matters in 1859? Let us hear Mr. Darwin, who may be trusted always to state the case against himself as strongly as possible.

"On this doctrine of the extermination of an infinitude of connecting links between the living and extinct inhabitants of the world, and at each successive period between the extinct and still older species, why is not every geological formation charged with such links? Why does not every collection of fossil remains afford plain evidence of the gradation and mutation of the forms of life? We meet with no such evidence, and this is the most obvious and plausible of the many objections which may be urged against my theory." *

Nothing could have been more useful to the opposition than this characteristically candid avowal, twisted as it immediately was into an admission that the writer's views were contradicted by the facts of paleontology. But, in fact, Mr. Darwin made no such admission. What he says in effect is, not that paleontological evidence is against him, but that it is not distinctly in his favor; and, without attempting to attenuate the fact, he accounts for it by the scantiness and the imperfection of that evidence.

What is the state of the case now, when, as we have seen, the amount of our knowledge respecting the mammalia of the Tertiary epoch is increased fifty-fold, and in some directions even approaches completeness?

Simply this, that, if the doctrine of evolution had not existed, paleontologists must have invented it, so irresistibly is it forced upon the mind by the study of the remains of the Tertiary mammalia which have been brought to light since 1859.

Among the fossils of Pikermi, Gaudry found the successive stages by which the ancient civets passed into the more modern hyenas; through the Tertiary deposits of Western America, Marsh tracked the successive forms by which the ancient stock of the horse has passed into its present form; and innumerable less complete indications of the mode of evolution of other groups of the higher mammalia have been obtained.

* "Origin of Species," first edition, p. 463.

In the remarkable memoir on the phosphorites of Quercy, to which I have referred, M. Filhol describes no fewer than seventeen varieties of the genus *Cynodictis* which fill up all the interval between the viverine animals and the bear-like dog *Amphicyon*; nor do I know any solid ground of objection to the supposition that in this *Cynodictis-Amphicyon* group we have the stock whence all the Viveridæ, Felidæ, Hyænidæ, Canidæ, and perhaps the Procyonidæ and Ursidæ, of the present fauna have been evolved. On the contrary, there is a great deal to be said in its favor.

In the course of summing up his results, M. Filhol observes:

"During the epoch of the phosphorites, great changes took place in animal forms, and almost the same types as those which now exist became defined from one another.

"Under the influence of natural conditions of which we have no exact knowledge, though traces of them are discoverable, species have been modified in a thousand ways: races have arisen which, becoming fixed, have thus produced a corresponding number of secondary species."

In 1859, language of which this is an unintentional paraphrase, occurring in the "Origin of Species," was scouted as wild speculation; at present, it is a sober statement of the conclusions to which an acute and critically-minded investigator is led by large and patient study of the facts of paleontology. I venture to repeat what I have said before, that, so far as the animal world is concerned, evolution is no longer a speculation, but a statement of historical fact. It takes its place alongside of those accepted truths which must be taken into account by philosophers of all schools.

Thus when, on the first day of October next, the "Origin of Species" comes of age, the promise of its youth will be amply fulfilled; and we shall be prepared to congratulate the venerated author of the book, not only that the greatness of his achievement and its enduring influence upon the progress of knowledge have won him a place beside our Harvey; but, still more, that, like Harvey, he has lived long enough to outlast detraction and opposition, and to see the stone that the builders rejected become the head-stone of the corner.—*Nature.*

ATMOSPHERIC DUST.*

By GASTON TISSANDIER.

EVERY one is aware that the atmosphere holds quantities of dust in suspension. The dust betrays its presence by settling upon our clothes, furniture, and other objects, but, on account of the minuteness of its particles, it can not be seen as it floats in the air, except under

* Translated and abridged from the "Revue Scientifique."

the illumination of a strong light, as in the case of a sunbeam shining into a dark room. Besides the grains of dust which may be seen in this manner, there are others that can be perceived only through the microscope, and others smaller still, little nothings like nebulosities in the sky, which seem to become more numerous as they are sought for with more powerful instruments. These bits of dust, lifted up and carried hither and thither by the atmospheric currents, must not be overlooked, for they play a part of considerable importance in terrestrial economy, and give rise to real geological formations. Clouds of impalpable dust, falling from the air in showers of considerable abundance, are not uncommon in some countries, and have been noticed in all periods of history. Showers of blood have also been mentioned quite often from the times of Homer down; they are showers of rain-water made muddy with the atmospheric dust, and bearing a yellow or reddish deposit. Showers of dust, both dry and wet, are quite frequent in the Cape de Verd Islands, and are called red fogs by the sailors. They are also common in Sicily and Italy, and occur so often in some parts of China as hardly to attract remark. The Chinese account for them by saying that the dust is lifted up by whirlwinds in the Desert of Gobi, is carried by the aërial currents into the higher regions of the atmosphere, falls at a distance, and is then swept up by rain-waters and carried by the rivers to be deposited at the bottom of the Yellow Sea. A shower of very fine dust which fell in southern France in October, 1846, was found, by the analyses of M. Dumas and the microscopic tests applied by M. Ehrenberg, to be composed of the fine sands of Guiana and to contain the characteristic diatoms and microscopic shells of South America.

Fig. 1.—Corpuscles extracted by the Magnet from the Dust deposited on a Surface of Twelve Square Metres at Sainte-Marie-du-Mont, Manche. (600 Diameters.)

Some of these showers originate in volcanic eruptions, from which fine ashes are projected up into the atmosphere, transported to a distance, and deposited over regions of considerable extent. A volcano of the Island of Sumbawa, in 1815, covered with ashes a space of three or four times the extent of France; the event left such an impression that the people at Bruni, in Borneo, made it an epoch from which they reckoned their dates. In some places the atmospheric currents of dust exert a perceptible mechanical action. Sir Joseph Hooker remarked, when he was in South America, that the aërial sand-currents on the tops of high mountains were competent to wear down and polish the trunks of trees and produce striæ upon them like that made upon rocks by glacial action. M. Videt d'Aoust has found evidence in Mexico of the formation of beds by the settlement of the dust, covering the largest mountains, as Popocatepetl and Orizaba, rising to the height of about 12,000 feet on the slopes and reaching a thickness in the valleys of from 250 to 325 feet. These formations are occasioned by whirlwinds of dust which are frequent on the Mexican plain, and are stopped by the elevated chain of the mountains, as the mud in a river is stopped by a sand-bar. The action of the prevailing winds in other parts of the globe promotes the formation of similar deposits, which may be called aërial lands.

These are the dusts of the lower regions of the atmosphere. But the air contains other particles in the most minute degree of division. The waters of the sea, impinging on the coast in waves, are broken into thousands of particles which are taken up and evaporated by the winds. The saline residue of these particles adds a new element to the atmospheric dust; the vapors furnished by the sea go to the formation of clouds and fogs. Rising beyond the regions of ordinary clouds, these vapors ascend to the colder strata, where they are converted into a dust consisting of minute crystals of ice which form the cirrhus clouds and the ice-fields of the upper regions. These masses of frost, which can only be distinguished when they are approached by a balloon, but the existence of which is well established, are agents in the formation of halos and parhelia, and descend in cold winds to the surface.

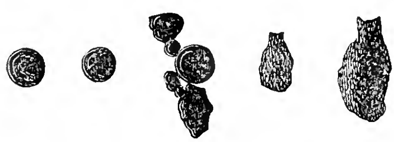


Fig. 2.—Corpuscles extracted by the Magnet from the Sediment of Rain-water at Sainte-Marie-du-Mont, Manche. (500 Diameters.)

If we pass these heights, into the extreme limits of the atmosphere, we shall find ourselves in the presence of dust from a new source—of that which is furnished by the combustion of incandescent aërolites. The fruits of the study of meteoric astronomy prove that the surface of the earth is continually receiving cosmic materials either in the form of meteorites or shooting-stars, or of an impalpable dust. A ship passing to the south of Java in January, 1859, was assailed by a very fine ferruginous dust. Ehrenberg examined some of it with the microscope, and found that it was formed of melted globules of oxide of iron, and did not hesitate to regard it as consisting of particles of a mass of meteoric iron, which had been melted off by the operations of atmospheric friction. In other cases the particles may originate in the disintegration of the substance of the meteors, when the soluble salts with which they are cemented are dissolved by atmospheric moisture, as Daubrée observed in the case of a meteorite at Orgueil. Showers of fire have been mentioned, or of sparks which seem to be formed of the incandescent dust of aërolites. Baron Reichenbach collected on the summit of Lahisberg a black ferruginous dust containing traces of nickel and cobalt, which incontestably indicated its cosmic origin. Mr. Nordenskjöld collected a similar dust from off the snow of the polar regions.

For several years I have paid attention to the study of atmospheric dust, and believe that I have proved that more or less considerable quantities of dust derived from cosmic bodies are constantly present in the air. The greater part of my experiments have been performed in the meteorological observatory of Sainte-Marie-du-Mont, Manche, where M. Hervé-Mangon has placed the resources of his establishment and laboratory at my disposition. I have endeavored to collect large quantities of dust, so that I might carry on microscopic and chemical analyses with precision. For this purpose I used a surface of paper of two square metres, which I exposed horizontally to the air; I collected from it the dust which fell from the air, sweeping it up with a small brush. I called this apparatus a dust-table. The weight of the dust collected upon this surface at Sainte-Marie-du-Mont varied from two to nine milligrammes (.03 to .14 grains troy) in twenty-four hours. The particles shown in Fig. 1 represent minute grains of magnetic oxide of iron, which were drawn out from the dust by the magnet. They are greatly magnified, their real diameter being only $\frac{1}{10}$ of a millimetre ($\frac{4}{1000}$ of an inch).

If we evaporate considerable volumes of rain-water, we shall obtain a sediment which represents the air-dust; if, then, we draw a magnet through this sediment, we shall nearly always find little globules of magnetic oxide of iron in it. Fig. 2 represents some of these globules, which I extracted from one hundred quarts of rain-water at Sainte-Marie-du-Mont.

We can distinguish several of these grains which have the form of spherules, or granules that have undergone fusion. The sediment from rain-water collected in Paris at the School of Bridges and Highways at the Trocadéro and the dust collected in one of the towers of Notre Dame gave identical results (Fig. 3).

Fig. 3.—Corpuscles extracted by a Magnet from the Dust brought in by the Wind in a Tower of Notre Dame which is closed to Visitors. (500 Diameters.)

These facts prove conclusively that the air holds in suspension minute microscopic particles of oxide of iron, some of which assume the form of well-defined spherules.

Similar spherules may be found everywhere in the dust of the air and in rain-water and snow-water. I have found them in the sediment of snow-water collected at the height of 8,800 feet on Mont Blanc (Fig. 4). Since I have called attention to the existence of these ferruginous bodies in the air, several men of science have confirmed my observations, particularly M. Yung, of the University of Geneva, and MM. Schoenaur and Pierre Miquel, who have pursued the study of the

Fig. 4.—Corpuscles extracted by the Magnet from the Sediment of Snow-water on Mont Blanc, 8,800 Feet above the Sea. (500 Diameters.)

air-dust at the observatory of Montsouris under the direction of M. Marie-Davy.

Whence are these ferruginous particles derived? The spherules have been melted: we can prove this by burning particles of iron and observing them under the microscope (Fig. 5); those which fly off on the striking of a flint are like them (Fig. 6). The spherules we are considering are probably derived from the showers of fire that escape

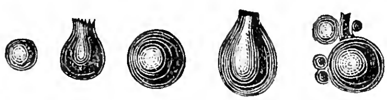


Fig. 5.—Globules of Magnetic Oxide of Iron obtained by burning Fine Iron Filings in a Hydrogen Flame. (500 Diameters.)

from incandescent meteorites. I have been confirmed in this view by observing with the microscope the crust of the aërolites in the collection of the Museum of Natural History, in which were perceived rounded grains having considerable resemblance to those we have just noticed. Moreover, the magnetic particles withdrawn from atmospheric sediments have given on analysis reactions indicating the pres-

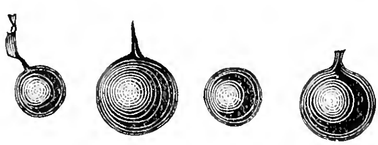


Fig. 6.—Spherical Globules of Magnetic Oxide of Iron obtained by collecting the Sparks struck off by a Flint. (250 Diameters.)

ence of nickel; of a character, consequently, to cause them to be regarded as partaking of the nature of meteorites. It may be objected that metallurgical operations and the production of oxides in iron-works give rise to similar ferruginous corpuscles. This is true; but how can we explain the presence of the spherules in geological formations that have not been worked over, where they must have been left previous to the existence of man on the earth? M. Stanislaus Meunier and I have found in the grits below the Lias, in the micaceous slates of the

Trias, magnetic globules like the spherules which now fall from the atmosphere upon the earth ; we may, according to our theory, consider them fossil meteorites.

Beautiful and peculiar crystalline forms (Fig. 7) are obtained when a drop of rain-water or snow-water is evaporated to dryness, the substance of which consists of the nitrate of ammonia contained in meteoric waters.

The dusts that are produced by man in works of industry expose him to terrible dangers. Stone-dressers breathe very minute particles of grit

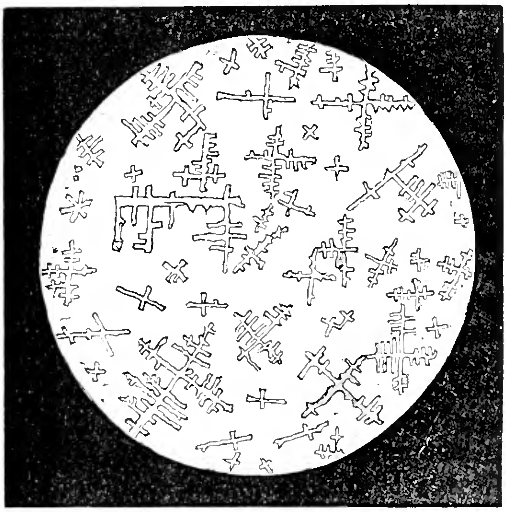


Fig. 7.—Crystals obtained by evaporating to Dryness a Drop of Snow-water. (500 Diameters.)

which perceptibly injures the lungs ; the dust of white-lead, and that of the arsenite of copper, which is used to color cloths and papers, have often produced genuine poisonings. The dust of coal, with which the galleries of coal-mines are filled, is breathed by the miners, and produces an affection which Dr. Riembault, of St.-Etienne, has designated as the carbonaceous obstruction of the lungs of miners. He has dissected the lungs of workmen who had labored in the mines for a greater or less length of time, and has found that this pulmonary obstruction goes on continually increasing till it becomes very dangerous. Sections of the lungs of miners show a gradual progress of coloration, from the fresh, rosy color of the lungs of a person who has always lived in the open air, to gray after a few years, and a blackness approaching that of the coal itself after forty years of labor in the mines. The dust of coal in the mines, when raised up and ignited, either by a blast or by the burning of a little carburetted hydrogen, has sometimes spread fires to great distances in the galleries, burning the workmen and producing terrible catastrophes. M. Galloway has made some important researches on this subject, and has shown that, even if the dust of coal is not directly inflammable, it becomes very combustible when the atmosphere contains traces of carburetted hydrogen. Other dusts are directly combustible, and sometimes produce genuine catastrophes by the fact of their suspension in the air. In 1869 a sack of starch was accidentally thrown down from the top of a staircase in the Rue de la Verrerie, Paris ; it burst and scattered through the air a cloud of dust which took fire from the contact with a gaslight at the bottom of the stairs, and caused an explosion. M. Berthelot has observed that special conditions of mixture are required for the actual production of such explosions, and that a hundred cubic metres of air, containing about thirty kilogrammes of oxygen, will completely burn twenty-seven kilogrammes of starch-powder, or eleven kilogrammes of coal-dust. The terrible explosion in the flour-mills at Minneapolis, Minnesota, in May, 1878, was of a similar nature with the explosion of the starch in the Rue de la Verrerie.

THE FOSSIL MAN.

By HENRY W. HAYNES.

PREHISTORIC Archæology, the latest-born of the sciences, like her elder sister Geology, has lived through the successive stages of scornful denial, doubt, and unwilling assent, and has finally won for herself substantial recognition. The "antiquity of man" is now an established fact. Even its most strenuous opponents are forced to concede that there are proofs of his existence during a lapse of time far exceeding the limits of the previously approved chronology. For somewhat of the suspicion with which this result has been received, certain of its advocates may have themselves to blame. Where absolute chronological determinations were of necessity impossible, and where, even at the present stage of the investigation, only general approximations can be reached, it was at least injudicious to startle received opinions, and to arouse prejudices, by asserting for mankind an antiquity of hundreds of thousands of years. Moreover, the great name of Cuvier was held up as a barrier in the path of those who claimed to have discovered proofs of man's existence under geological conditions differing from the present. Cuvier, however, never *denied the possibility* of finding "the fossil man" ; he only questioned the sufficiency of the evidence of his existence which had been brought under his notice, and with great reason, in view of the numerous instances in which pretended fossil human bones had turned out to be those of animals, or even merely natural formations.

Many have been the definitions given of the term "*fossil*"; but by the phrase "the fossil man" is intended in this article *man as the contemporary* of certain species of animals now either *totally or locally extinct*, which we know only from their bones, *dug out* of the earth, but as to whose existence history and tradition are silent. Such animal remains are found, mingled with those of species still living; but they occur under geological conditions which show that the formerly existing surface of the earth differed in certain respects from its present state. This geological epoch, the nearest in point of time to the present, is called the Quaternary period. It is characterized by extensive deposits of rolled and water-worn pebbles, gravels, and clays, underlying the cultivable surface-soil, and due to the action of former extensive glaciers and of great and rapid currents of water. These latter were produced by the melting of that sheet of snow and ice which once covered large regions of the northern portions of Europe and America, combined with a climate much more humid than the present, and a consequent greater rainfall. This moister climate arose from a different relative arrangement of the then existing continents and seas. The general contour of the earth's surface, then, so far as existing elevations are concerned, seems to have resembled very nearly its present appearance; thus these great currents in many instances took the courses of the present river-systems in northern and central Europe and North America. The Quaternary deposits, consequently, have often been left in the neighborhood of existing streams, which now seem like shrunken rivulets in comparison with these mighty rivers of old. Through these deposits and the underlying strata the present rivers have cut their channels, leaving the Quaternary gravel-beds sometimes as high up as two hundred feet on the slopes of their valleys. In some cases oscillations of level of the surface, or other causes, have left such deposits where there are no longer existing rivers. They are, however, all characterized by similar features, and are called by geologists indifferently *Quaternary gravels* or *drift;* while the beds composed of the finer particles, often of great thickness and spread like a carpet over extensive plateaus, are named *loess* or *brick-earth.* That such beds of gravel or loess were not deposited by the sea is proved by the fact that such animal remains as occur in them are all those of land or fresh-water, and never those of marine, species.

But it is not only in the Quaternary gravels and loess that the bones of extinct animals are found; they occur more frequently in numerous caverns and fissures in the rocks. As these are met with most commonly in limestone formations, the bones are in consequence generally imbedded in or covered by a stalagmitic formation, produced by the percolation through the roof of water charged with carbonate of lime. Such a floor of stalagmite, sometimes of great thickness, covering and completely sealing up the contents of the underlying beds, is at once a proof of their antiquity and a guarantee against the possibility of such contents having become confused with objects of a later date.

In such Quaternary gravels and caverns mingled with the bones of numerous extinct species of animals, such as the mammoth, the woolly rhinoceros, and the cave-bear and others, human bones have been discovered, although comparatively rarely, while the implements and objects of man's fabrication are found in large quantities. They are, however, all made of stone, or of the horns and bones of animals. Such human remains as have been discovered show man at this earliest epoch to have been possessed of a cranial development quite equal to the average now. Already the anthropologists have been able to establish the existence of at least three different races, named, from the localities in which the skulls have been discovered, the races of Canstadt, of Cro-Magnon, and of Furfooz—caverns situated respectively in Germany, in France, and in Belgium. But implements and weapons of undoubted human workmanship are as good proof of man's existence as his actual bones ; nor is the scarcity of these latter limited to Quaternary times. None were found, for example, when the great Haarlaem Lake was drained, although many a bloody sea-fight had taken place on its broad bosom.

Nor is it in rare and special localities alone that traces of early man have been found. They are met with in England, in France, in Belgium, in Switzerland, in Germany, in Italy, in Spain and Portugal, and in southern India ; and in the winter of 1878 I was fortunate enough to discover them in Upper Egypt, where hitherto their occurrence has been either denied or doubted. Our own continent, too, seems to be not wanting in them, as within the past few years they appear to have been discovered by Dr. Abbott in the glacial drift of the valley of the Delaware. The field is vast and the laborers have been few, but their numbers are rapidly increasing ; and, as extended research has been constantly rewarded by repeated discovery, we have every reason to expect that there are most important results yet to be reached, both on this continent and in the almost unexplored regions of Asia, the acknowledged cradle of the human race, where thus far only slight traces of early man have been met with.

But though the antiquity of man is admitted, and the fact of his coexistence with extinct animals during the Quaternary period can not be denied, yet both the duration of the Quaternary period and the question of his existence in the previous Tertiary age are still stoutly contested. The proofs of his presence in Tertiary times are as yet "few and far between," and the believers in his existence at that remote epoch are by no means numerous ; still, as History so oft repeats herself, it may well happen that the late Abbé Bourgeois, of Pontlevoy, who has been thus far the principal champion of the Tertiary man, may share in the eyes of posterity in the well-merited honors of Boucher de Perthes, of Abbeville, who first established the existence of "the fossil man." Whether the duration of Quaternary times extends over a period of one hundred thousand years or more, or twenty thousand, or even less, is immaterial, and probably never can be absolutely determined. The chronological scale is too uncertain, with conditions varying according to locality and circumstances, to give ground for great hope of success. Still, who shall venture to set a limit to the triumphs of science? The methods of prehistoric archæology are scientific; its votaries are steadily increasing in numbers; its progress has been marvelously rapid, and we may with confidence await the result.

The most remote *historical* date thus far even approximately determined is that of the early dynasties of Egypt, although even on this point the authorities differ by as much as a thousand years. Taking, however, the lowest computation, we find, some four thousand years B. C., a flourishing civilization established in Egypt, with a condition of the arts, especially of statuary and of architecture, fully able to stand the test of comparison with those of the present day, but which afterward steadily degenerated under the iron rule of the priesthood. This date has been reached by the light of written inscriptions, so that the *history* of mankind has thus been carried back to a point of time as remote as that of his creation, according to the belief of our fathers. Now, a flourishing civilization with admirable arts, and especially a fixed literary language, presupposes ages of development and progress, so that we see the "prehistoric man" thrust thus at least one stage into "the dark backward and abysm of time." But only monuments inscribed by Nature's own hand are our helpers in the arduous task of attempting to measure by a scale of centuries the duration of the existence of "the fossil man." The slow excavation of certain river-beds during the present geological period, thus bringing to light in their banks relics of man, above which the soil has accumulated in depths varying according to known historical periods; the secular growth of peat-mosses and of films of stalagmite; the deposit of cones of detritus at the mouths of mountain-torrents; the leisurely filling up of lakes by the accumulation of soil washed down from neighboring mountains —such are the sole standards of measurement that have thus far been devised for the careful computations or the wild guesses of those who have hitherto essayed the difficult problem. Its final determination must properly be left to the geologists, some of whom regard the Quaternary period as more justly to be assigned to the present stage of the earth's history than as constituting a past geological epoch rightly so called. But the discovery of traces of early man in regions widely remote from each other, and especially in countries where the earliest civilizations have arisen, is a complete answer to the objections of those who would make of "the fossil man" only a savage race localized in western Europe in times not far removed from those of which history takes cognizance.

Among the many attempts that have been made to reach a solution of the problem, the most satisfactory, perhaps, have been the systematic explorations that have been carried on without interruption since

1865, by a most competent committee of the British Association, of a large cavern in south Devonshire, near Torquay, called "Kent's Hole." I have had the opportunity of personally studying the modes of procedure there under the guidance of Mr. Pengelly, secretary of the committee, and can bear testimony to the scrupulous care, the vigilant watchfulness, and the great skill and knowledge with which the investigations are prosecuted. The following is a brief sketch of what has been discovered in the course of the exploration: The bottom of the cavern was found to be encumbered with huge blocks of limestone that had become detached from the roof, between and under which was a layer of vegetable mold of varying depths up to a foot or more. In this layer were found objects of various periods, running back as far as the times of the Roman occupation of the island. Below this came a floor, a stalagmite of an average thickness of sixteen to twenty inches, and underneath it a layer of cave-earth four feet deep, in which were found objects of man's fabrication. Still lower they came upon a second floor of stalagmite, which in some places had attained a thickness as great as twelve feet. Below all came a breccia, in which were found numerous teeth and bones of the cave-bear, and with them three undoubted flint instruments. Now, in one part of the cavern there is a huge boss of stalagmite rising from the floor, and on it is inscribed "Robert Hedges, of Ireland, February 20, 1688." For nearly two hundred years the process of the formation of stalagmite appears to have been going on, and still the letters are now only covered by a film of not more than one twentieth of an inch in thickness. Even granting that the deposition of stalagmite may have proceeded much more rapidly under former conditions than at present, when more water and more carbonic acid may have penetrated the cavern, still it is evident what a lapse of time is required to account for the formation of such a mass of material as we have here. Nor can accident or fraud be invoked to explain the presence of these relics of man, under the circumstances in which these have been found. The work was executed under the daily supervision of the committee, and by trustworthy laborers, and no intermingling of objects falling from a higher level; no burying of them in later times in excavations made in an older deposit; no attempt at making gain from forged articles palmed off upon credulous collectors in this case is possible. Like results have been reached by the same committee in the "Brixhaw Cave," on the opposite side of Torbay, which was purchased and thoroughly explored by them immediately after its accidental discovery in 1858, through its roof having been broken into in quarrying. In this case the additional guarantee was afforded for the genuineness of the contents, that its exploration was almost contemporaneous with its discovery. Space will not allow more than an allusion to the laborious and fruitful researches of the late Messrs. Lartet and Christy in the caves and the rock-shelters of the valley of the Dordogne and its affluents, in the south of France. By their labors and those of the numerous band of explorers who have followed in their footsteps in the same country, and by the discoveries of M. Dumont in the valley of the Meuse in Belgium, we have been enabled to gain some definite knowledge in regard to "the fossil man," his manner of life, his implements and weapons, and even his artistic capabilities.

The "classic ground," however, for the student of prehistoric science must ever be the Somme Valley, from Abbeville to Amiens. From its Quaternary gravels came those rude flint implements with which Boucher de Perthes succeeded at last in silencing the cavils of the incredulous, and establishing the coexistence of man with extinct species of animals. St. Acheul, an old abbey close to Amiens, has given the name to these objects, which are the most ancient type of man's workmanship hitherto met with, for in its vicinity they have been found in greater quantities than in any other locality. When first discovered they were called by the workmen "cats' tongues," from their shape and roughness. In outline, form, and general appearance they are perfectly characteristic, and they differ entirely from all other stone implements which have ever been discovered under different conditions. No one who is at all familiar with the subject can possibly confound one of these *palæolithic* axes, as they are called, roughly chipped and unground, with one of the *neolithic* or polished-stone times. These latter are found in large numbers, and substantially resembling each other all the world over, and are mainly relied upon to prove that everywhere man has at some time lived in a stage of culture, in which he had not attained to the knowledge of the use of metals. The palæolithic weapons, however, or the St. Acheul axes, are of much rarer occurrence. But, if a collection of specimens from various localities, including our own country, be placed side by side, their resemblance to each other will be found to be most striking. At St. Acheul I had the satisfaction of seeing dug out in my own presence, from gravel-pits now more than a quarter of a mile from the river, and one hundred feet or more above its present level, and in a spot overtopped by no higher ground from which anything could possibly have been washed down, two such implements. These, though unfortunately broken, are yet as convincing, from their excellence of workmanship, as if they were still perfect. In this case there was no possibility of deception, through their having been buried beforehand, for me to see them dug out, since I came to the spot unannounced. The workmen at this place know well the value of such objects, and have the habit of fabricating them for sale. If, however, one of their forgeries be placed by the side of a genuine object, there will be found to exist certain infallible tests by which to discriminate between them, so that there need be no mistake. Freshly broken flint presents a peculiar dull and raw surface, entirely unlike the glossy, varnished appearance of objects which have undergone a long exposure to atmospheric influences, and have been subjected to chemical changes and the friction of sand and water. These causes produce the characteristic "patina," which distinguishes genuine flint implements, and which varies greatly according to the conditions under which the objects have remained. It is of very different colors, but has never been successfully imitated by artificial means. Many of the implements also, like mine, are marked by a beautiful moss-like deposit of oxide of manganese, called "dendrites," which is an additional guarantee of their genuineness, as it is only produced by a long lapse of time. In the gravel-pits in the neighborhood of Paris, on both banks of the Seine, in many visits ranging over several years, I have been able to procure a large number of worked flints, together with the usual fossil bones that accompany them. So, too, in similar excavations at the Ponte Molle, near Rome, at a long distance from the present bed of the Tiber, and far above the limit of any possible inundation now, I have obtained numerous specimens both of flints and bones.

To go thoroughly over the arguments of the geologists, by which the very great antiquity of such Quaternary deposits with their contents has been established, would require more space than is at my command. I will simply state a few facts, leaving others to draw their own inferences from them. Implements of the St. Acheul type have been found in place at the bottom of undisturbed gravel-beds more than thirty feet deep, both at Abbeville and at Amiens, and in the former locality peat-beds have been subsequently formed in the more deeply excavated portion of the valley more than thirty feet in thickness. Now, whatever may be the lapse of time needful for the accumulation of such a mass of peat as this, it is all posterior in date to the ancient implement-bearing gravels. At Amiens Roman graves have been found in the superficial deposits at about the present level of the river, and far below that of the Quaternary gravels, showing that more than fifteen hundred years have produced scarcely any change in the configuration of the valley, so far as its depth is concerned. So, too, on the top of Milford Hill, in the neighborhood of Salisbury, England, are found Quaternary gravels containing implements of the St. Acheul type. This hill is cut off from the main spur to which it belongs by a transverse valley, which proves that, at the time when the gravel was deposited there, such a depression could not have existed, as in that case the water would have flowed along the valley, and not left its contents on the top of the hill. On each side of the hill is also a similar valley, which, for the same reason, could not have been there when the gravel was deposited. Thus the top of the hill once formed the bottom of the bed of a river flowing along a valley whose sides have now entirely disappeared, and in their place a new valley has been excavated on each side to the depth of one hundred feet.

That these Quaternary gravels can not be owing to any sudden cataclysm is proved both by the regularity with which they are deposited, and by the fact that the materials of one river-system are never found mingled with those of another. For example, the gravel-beds of the Somme Valley are entirely composed of *débris* from the chalk and Tertiary strata occupying that area. But within a very few miles of the head-waters of the Somme comes the valley of the Oise. This latter valley contains the remains of other and older strata, none of which have ever found their way into the Somme Valley, as would certainly have been the case if any great and sudden inundation had ever swept over the surface of the whole country.

From such considerations as these, and many others that might be brought forward, prehistoric archæologists are united in the opinion that the St. Acheul axes found in these Quaternary deposits, and in certain caverns, accompanying the bones of the same fossil animals, are relics of the earliest phase of man's existence yet discovered. Of course, the few are excepted who maintain the belief in the Tertiary man. Such implements have been searched for and found in many countries, but there was still one unfortunate hiatus in the line of argument. It was objected, if such evidence of the great antiquity of man has been discovered in so many different regions, Why is it not to be found in Egypt, the oldest country of which we have direct historical knowledge? This question several have attempted to answer, but hitherto they have failed of complete success. This was owing to the nature of the case, and the peculiarities of the country. Most travelers spend the winter months in their *dahabeeahs*, ascending and descending the Nile, and have little leisure for long and patient researches; while the distinguished scholars who have resided for long periods in the country have been exclusively occupied with studying its numerous historical monuments, and no one of them has had any special acquaintance with or interest in the *prehistoric question*. It is true that M. Adrien Arcelin and Sir John Lubbock, and also Dr. Haury with M. Lenormant, who all made the usual Nile trip, have published articles on the subject, some of them figuring in plates certain worked flints discovered by them in Egypt. But they did not succeed in satisfying prehistoric students that they had actually discovered evidence of the *Palæolithic age* in that country. That they had indeed found *worked flints* there, could not be questioned by any one who has had competent experience in the subject, though even this has been denied by the distinguished Egyptologist, Lepsius. Some have even supposed that such objects may have been used by the poorer classes within the historic period, of which the paintings and sculptures in the tombs give us such vivid glimpses. The opening of an hotel at Luxor, in Upper Egypt, the site of ancient "hundred-gated" Thebes, in the winter of 1878, gave me an opportunity of carefully studying the question on the spot. I remained seven weeks and searched the region thoroughly in various directions, so far as was possible in journeys of one day's length. The

Nile Valley here is bounded on each side by hills of Tertiary limestone on whose flanks the present surface-soil rests without any intervening Quaternary deposits. On the western or Libyan side these hills are pierced by many dry ravines, or wadys, through which the desert sands make their way down toward the cultivable strip of alluvial soil on the bank of the river. Though Upper Egypt is a rainless region, still occasionally, perhaps once in twenty years, heavy rains occur, and great torrents tear their way down these wadys into the Nile. In the bottom of such ravines, and occasionally on the elevated plateaus of the hills, I succeeded after long and toilsome searching in finding several implements of the true St. Acheul type. I also found innumerable examples of all the various objects that are commonly discovered in other countries, in which the existence of "the stone age" is considered to be established. These were axes, scrapers, piercers, knives, flakes, nuclei, etc., together with some forms that were entirely novel, and all without exception were made by the process of chipping. Although polished implements have been occasionally discovered in Egypt, I have never myself happened to find a single example. Some few objects were met with in the eastern desert; but on the Arabian side the valley is so much wider that it is almost impossible to reach the hills in one day and have any time left for searching. At Paris I showed the objects I had discovered to M. de Mortellet, curator of the prehistoric department of the great museum of St. Germain-en-Laye, under whose charge had been placed the organization of the anthropological department of the late French Exhibition. By him I was requested to place them there, where they were seen and examined by many scholars from various countries occupied with prehistoric studies, and by all they were pronounced to be true palæolithic objects. Quaternary deposits do not occur in the Nile Valley, so far as I am aware, though they have been found in various parts of the Sahara. Consequently it is only in such spots as those in which these implements were discovered, that any relics of the early man can now be met with there. If man lived in Egypt at that remote epoch, most traces of him must now lie buried under hundreds of feet of Nile mud, the product of the annual inundation of the river for countless ages. The discovery, therefore, in the Nile Valley of all the usual types of objects of "the stone age" in other countries, including those of the most remote times, would seem to furnish a sufficient reply to the objections of such as maintain that no traces of "the fossil man" have been discovered in Egypt.

A ZOÖLOGICAL ENIGMA.

By FELIX L. OSWALD, M. D.

PROFESSOR ULRICI, the modern Rosicrucian, defends spiritualism on the plea that it meets the demands of what he calls our *Wunderbedürfniss*, the propensity to indulge in wonderment, which he includes among the normal instincts of the human mind. A taste for enigmas is a primitive manifestation of the thirst for knowledge in general, and thus akin to the very *primum mobile* of all intellectual progress, but in its legitimate forms that propensity might exert its functions on an ample field within the domain of the strictly physical sciences. The problems of modern chemistry, physiology, and natural history confront us with countless unsolved questions, with phenomena more wonderful in their reality than any dreams of hysterical hallucinations or of the wildest fancy. The marvel-hunter who gropes his way through the arcana of an unknown world might pursue his quarry more profitably on the hunting-grounds of his own planet—more successfully, too, if he would keep his eyes open. The sunlit fields and the gaslit laboratory reveal truer wonders than the dark closet of the spook-manufacturer ; the tests of the naturalist yield the same result at all times and under all circumstances—their success does not depend on the obfuscation of the locality (and of the witnesses) ; it is not jeopardized by the presence of skeptical critics, or the absence of discreet accomplices. Many notorious phenomena, apparently familiarized by their frequency, in reality still involve mysteries whose solution might disclose new paths of research, or reflect a helpful light upon the problems of a kindred science. The diffusion of contagious diseases, submarine currents, the synchronism of storms and shooting-stars, hibernation, the survival of reptiles in close-grained rocks, the weather-wisdom of the tree-toad and trap-door spider, for instance, have been only partially explained ; nay, every amateur naturalist may indulge in an experiment whose general result seems so utterly inexplicable on any recognized scientific principle that it reduces our speculations to a phraseology of metaphors—to the nomenclature of an unknown quantity.

We often hear of the wondrous sagacity—generally ascribed to memory or acuteness of scent—which enables a dog to find his way home by unknown roads, even from a considerable distance. I think it can be practically demonstrated that this faculty has nothing to do with memory, and very little with *scent*, except in a quite novel sense of the word.

Last fall, my neighbor, Dr. L. G——, of Cincinnati, Ohio, exchanged some suburban property for a house and office near the City Hospital, and at the same time discharged a number of his four-footed retainers. A litter of poodle puppies were banished to Covington, Kentucky, across the river, and two English pointers were adopted by a venatorial ruralist in the eastern part of Ohio. The puppies submitted to exile, but one of the pointers, like the black friar in the halls of Amundeville, declined to be driven away. He returned, by ways and means known to himself alone, once from Portsmouth and twice from Lucasville in Scioto County, the last time in a blinding snow-storm and under circumstances which led his owner to believe that he must have steered by memory rather than by scent. But how had he managed it the first time? The matter was discussed at a reunion of sportsmen and amateur naturalists, and one opponent of the doctor's theory proposed as a crucial test that the dog be chloroformed, and sent by a *night-train* to a certain farm near Somerset, Kentucky (one hundred and sixty miles from Cincinnati): if he found his way back, he could not have done it by memory.

The doctor objected to chloroform, remembering that dogs and cats often forget to awake from anæsthetic slumbers; but finally Hector was drugged with a dose of Becker's elixir (an alcoholic solution of morphine), and sent to Somerset in charge of a freight-train conductor. The conductor reports that his passenger groaned in his stupor "like a Christian in a whisky-fit"; at length relieved himself by retching, and went to sleep again. But in the twilight of the next morning, while the train was taking in wood at King's Mountain, eighteen miles north of Somerset, the dog escaped from the caboose and staggered toward the depot in a dazed sort of way. Two brakemen started in pursuit, but, seeing them come, the dog gathered himself up, bolted across a pasture, and disappeared in the morning mist. At 10 A. M. on the following day he turned up in Cincinnati, having run a distance of one hundred and forty-two miles in about twenty-eight hours.

Still the test was not decisive. The dog might have recovered from his lethargy in time to ascertain the general direction of his journey, and returned to the northern terminus by simply following the railroad-track backward. The projector of the experiment, therefore, proposed a new test with different amendments, to be tried on his next hunting-trip to central Kentucky. On the last day of January the dog was sent across the river, and, *nem. con.*, the experimenter fuddled him with ether, and put him in a wicker basket, after bandaging his nose with a rag that had been scented with a musky perfume. Starting with an evening train of the Cincinnati Southern Railroad, he took his patient southwest to Danville Junction, thence east to Crab Orchard, and finally northeast to a hunting rendezvous near Berea in Madison County. Here the much-traveled quadruped was treated to a handsome supper, but had to pass the night in a dark tool-shed. The next morning they lugged him out to a clearing behind the farm, and slipped his leash on top of a grassy knob, at some distance from the next larger wood. The dog cringed and fawned at the feet of his traveling companion, as if to conciliate his consent to the meditated enterprise, and then slunk off into a ravine, scrambled up the opposite bank and scampered away at a trot first, and by and by at a gallop—not toward Crab Orchard, i. e., southeast, but due north, toward Morgan's Ridge and Boonsboro—in a bee-line to Cincinnati, Ohio. They saw him cross a stubble-field, not a bit like an animal that has lost its way and has to turn left and right to look for landmarks, but, "like a horse on a tramway," straight ahead, with his nose well up, as if he were following an air-line toward a visible goal. He made a short *détour* to the left, to avoid a lateral ravine, but farther up he resumed his original course, leaped a rail-fence, and went headlong into a coppice of cedar-bushes, where they finally lost sight of him.

A report to the above effect, duly countersigned by the Berea witnesses, reached the dog's owner on February 4th, and on the afternoon of the following day Hector met his master on the street, wet and full of burrs and remorse, evidently ashamed of his tardiness. That settled the memory question. Till they reached Crab Orchard the dog had been under the full influence of ether, and the last thing he could possibly know from memory was a *misleading* fact, viz., that they had brought him from a southwesterly direction. Between Berea and Cincinnati he had to cross two broad rivers and three steep mountain-ranges, and had to pass by or through five good-sized towns, the centers of a network of bewildering roads and by-roads. He had never been in that part of Kentucky before, nor ever within sixty miles of Berea. The inclination of the watershed might have guided him to the Kentucky River, and by and by back to the Ohio, but far below Cincinnati and by an exhaustingly circuitous route. The weather, after a few days of warm rains, had turned clear and cool, so that no thermal data could have suggested the fact that he was two degrees south of his home. The wind, on that morning, varied from west to northwest; and, if it wafted a taint of city atmosphere across the Kentucky River Mountains, it must have been from the direction of Frankfort or Louisville. So, what induced the dog to start due north?

"Instinct." Of course, but the demands of science are not to be satisfied with conventional phrases. Blind instincts we may call such feelings as hunger, the craving after fresh air, and other promptings of our internal organs; also, perhaps, the faculty of executing such uniform mechanical functions as the construction of an hexagonal cell or of a spheroid cocoon; but, if such faculties have to adapt themselves to variable and uncertain circumstances, they require the aid of a sense—i. e., of a *discriminative* organ. So the question comes back upon us, What sense aided the dog in the choice of his direction? Scent? It seems too impossible, though the assumption of a "sixth sense" would be the only alternative. A blind man finds his way through the mazes of a city, or an intricate system of halls and corridors, by what we might call locomotive memory—i. e., the faculty to remember a long series of turns in their due sequence and with the correct intervals of time or space. The sense of touch becomes here vicarious to eyesight. In the same way a wide-awake animal might take cognizance of certain locomotive data without the assistance of its eyes. It might *feel* the turnings of its rolling cage, and remember enough to imply the general direction. A stupefied animal could not do it. The olfactory power of a dog exceeds ours about as much as human eyesight exceeds that of a shrew-mouse. A dog will "set" a covey of partridges across a broad field, and can scent a tramp from a distance of half a mile. A nose that can track the faint scent of a rabbit through thickets of aromatic herbage might easily distinguish the atmosphere of a reeking manufacturing town at a distance of ten miles. At fifty miles it might be barely possible under the most favorable conditions of wind and weather; at one hundred and fifty miles it seems impossible under all circumstances. Besides, a dog would find his way to a backwoods cabin as readily as to a smoky metropolis. The question still recurs: How does he manage it? Should dogs be gifted with the faculty of determining geographical latitude and longitude by means of their noses?

The memory-hypothesis being disposed of, the scent-theory might be definitely settled by a simple operation, viz., destruction of the olfactory nerve. Any anatomist could do it. Helmholtz and Von Graefe made similar experiments with the optic nerve, even without inflicting permanent damage. A dog might be rendered scentless for a day or two, and a trip to the next county under the above-described collateral precautions would decide the point. Deerhounds, pointers, and terriers would be the best subjects for the experiment; greyhounds are not only inferior in acuteness of scent but in sagacity in general; and collies and poodles, though marvelously clever in their peculiar spheres, seem to be almost destitute of what the French call the *sens d'orientation* (the sense of *orientation*—the process of determining the points of the compass).

Leaving the exegetical question out of view, I will here venture a conjecture in regard to the origin, or rather the original purpose, of the strange faculty. The common ancestor of all domestic dogs was probably some near relative of the *Canis lupus*, either the dog-wolf of the Hindoo-Koosh, or the *Canis aureus*, the Indian or African jackal. The puppies of all these canines are born in litters—from six to ten at a time, are helpless for the first ten weeks, and entail a great amount of trouble on their food-purveyors. The mother, perhaps straitened in her own means of support, has now to meet the demands of a greatly enlarged household, and in all probability the available supplies of animal food in her next neighborhood will soon be exhausted. Her forage excursions must be extended to greater and greater distances, in a barren country like northern Africa or Turkistan perhaps to remote oases and mountain-regions, hundreds of miles away. She-wolves that must have come from Lithuania or eastern Poland have been shot in northern Germany. Under such circumstances topographical instinct becomes a matter of vital importance, and where there is a want Nature always finds the means of supplying it. All our senses are comparatively rudimental. Every organ holds the possibility of an infinite functional development. In man the ability of distinguishing black from white has been perfected into the art of reading, the faculty of identifying at a single glance half a hundred multiform black marks on a white background. By constant practice and hereditary transmission of cumulative acquirements, the ability of remembering the bifurcation of a ravine, or of smelling a muskrat across a creek, was thus, perhaps, developed into the art of recollecting the ramifications of a vast mountain system or of scenting the atmosphere of a given locality athwart a continent.

Similar causes have produced similar results in other species of animals, for the sense of orientation is not confined to the genus *Canis*. Horses and goats show traces of the same talent; pigeons, crows, falcons, and all migratory birds possess it in a transcendent degree; also all migratory fishes and reptiles, shad, sturgeons, tunnyfish, and marine tortoises. Now, there is no doubt that in most birds the olfactory sense is very feebly developed. Eagles, falcons, and sparrowhawks hunt by sight, and even condors and other vultures have been decoyed with sham carcasses, hides stuffed with straw or stones. Pigeons and chickens are very sharp-sighted and awaken at the slightest sound, but a noiseless thief can surprise them in any dark night—the sense of smell does not warn them. Von Haller went so far as to assert that birds can not smell at all, and that their nostrils are only respiratory apertures.

How, then, could carrier-pigeons find their way from Cleveland to Philadelphia? Belgian pigeons have carried letters from Paris to Namur and from Geneva to Brussels, in fourteen and twenty-two hours; and a gerfalcon, which Henri Quatre presented to the commander of a Mediterranean brigantine, returned from Tangier to Paris in a single day. Did they steer by sight? However telescopic their vision might be, the incurvation of the globe would preclude the idea.

The bird-of-passage instinct is much less wonderful. Cranes and geese might steer due south by the aid of the noontide sun, and return by inverting the process till they come in sight of familiar scenery. A Northampton swallow, flying at the rate of two miles a minute, could well afford to roam at random over the State of Massachusetts till she came in sight of the Holyoke range and Mount Tom. A sturgeon, too, might find his spawning-grounds at the mouth of the Ottawa by following the St. Lawrence upward till he reached the Chaudière of St. Anne. In short, the art of retracing a self-chosen route appears much less enigmatical. But even reptiles have crossed unknown seas by the aid of the same geographical second-sight which guided the Philadelphia pigeons to their native roost. According to a well-authenticated report, the crew of a British East Indiaman caught an enormous tortoise near St. Helena, marked it with the brand of the company, and quartered it in the cockpit, but in the English Channel their captive crawled on deck and plunged overboard. Two years after, the same tortoise was caught in Sandy Bay near Jamestown, on the south coast of St. Helena. No ocean-current could have carried it there; it must have navigated by its inner compass a distance of seven thousand English miles.

Should the occult sense be merely an unknown function of a well-known organ? A person whose eyesight is limited to the range of his ear-shot would fail to comprehend how an earthly being could see stars beyond the boundaries of the solar system, and a nation of mole-eyed men would speak of the *instinct* that enables a *homo* of a different species to reach a distant village by keeping his eye on the steeple. We may have a dormant rudiment of that same sixth sense. Perhaps it awakens in the pulmonary beatitude that expands our chests in the atmosphere of a sunlit forest, or in the nausea induced by the effluvium of a stagnant bayou. Neither sensation is necessarily dependent on the olfactory sense.

We have lost several faculties from sheer disuse, but it is not probable that their number includes the instinct of orientation. It is deficient in many of our fellow creatures, both of the higher and lower orders. Monkeys, sheep, black cattle, gallinaceous birds, lizards, and lepidopterous insects seem to be almost devoid of it. Should we not be able to detect some characteristic structural difference between monkeys, chickens, and lizards on the one hand, and dogs, pigeons, and tortoises on the other? A peculiar instinct must correspond to some peculiar organization, and I think that specialty could be determined in the domestic dog if anywhere. For many reasons the *modus operandi* of a function can be more easily observed in a docile mammal than in a reptile or a shy bird, and, if we hope to force the intrenchments of the enigma, we had better "fight it out on this line." If one of the five senses should be the functional medium of the strange instinct, there must be ways and means to identify it; if there is such a thing as a sixth sense, we should be able to locate its organ. The "intuitive cerebration" theory is untenable. In the well-known axiom that nothing comes within the ken of our intellect but what has entered by the gate of the senses, we may confidently substitute "intuition" for "intellect." In other words, we have few reasons to doubt and many reasons to suspect that every psychic emotion, as well as perception, is the reflex of some organic impression.

ON THE MODES OF DISTRIBUTION OF PLANTS.

By JOSEPH F. JAMES.

THE study of the geographical distribution of plants over the earth is one of the most profound interest, not only to the botanist but to mankind in general. To the former it is of especial interest on account of the intimate relations existing between it and the origin of the different species of plants. Where we find an isolated example of a group of plants existing in one country, while its nearest congeners are in another perhaps thousands of miles off, we naturally feel interested in trying to discover the cause of this wide separation, and the means by which the plant has reached its present location. It is to the means of distribution that we shall devote this paper.

It is a trite remark that although there may be places identical in temperature, in soil, in humidity, and other circumstances governing the stations of plants in both North America and Europe, and in South America and Africa, still it does not necessarily follow that the species of plants in these identical localities are alike or even at all similar. Indeed, researches show it to be rarely or never the case. In almost every country, however, there seems to be a certain though sometimes a small proportion of plants which are found in other and distant parts of the world. For instance, Mr. Brown found that, out of 4,100 species of plants then known to inhabit Australia, 166 were identical with those of Europe, and that the greater proportion of these were eryptogamous plants, while those that were not were plants common to the intervening regions.* There are 359 indigenous plants out of the 2,277 phænogams given in the last edition of Gray's "Manual," which are also indigenous to Europe. A number, too, of the plants of eastern North America are common to northeastern Asia, China, Japan, and India. Out of a collection of 600 plants from the river Congo in Africa, Dr. R. Brown found thirteen which also grew on the opposite coasts of Brazil and British Guiana.† No less than one fifth of the algæ from the Antarctic seas, exclusive of the New Zealand and Tasmanian groups, have been identified by Dr. Hooker with British species.‡ A few of the most remarkable cases of distribution of identical species will no doubt be of interest here. *Sauvegesia erecta* grows in the Antilles, in Brazil, in Madagascar, and in Java; *Scirpus maritimus* grows in North America, in Europe, in western India, in Senegal, at the Cape, and in Australia; § *Brasenia peltata* grows in the United States, in Japan, in eastern India, and in

* Lyell, "Principles of Geology," ii., p. 387.

† Lyell, ibid., ii., p. 394.

‡ Lyell, ibid., ii., p. 389.

§ Jussieu, "Elements of Botany," p. 718.

Australia.* Several species of the mosses (*Funaria*, *Dicranum*, and *Bryum*) are common to the Blue Mountains of Jamaica, the Peak of Teneriffe, and Lapland.† Among 133 plants from one of the Pyrenees, Raymond found thirty-five identical with those of Melville Island in the Arctic Ocean.‡ *Potentilla anserina* grows in North America from Pennsylvania to California and northward, in the northern part of the Old World, in Chili, and in New Zealand ; *Monotropa uniflora* from Canada to Louisiana, in Oregon, in New Granada (South America), and Himalaya Mountains in India ; *Dichondora repens* from Virginia to Chili, in New Zealand, in Tasmania, to eastern Africa, and at the Cape of Good Hope ; *Adiantum pedatum* is found in the eastern United States and Canada, to Oregon, in Kamtchatka, Japan, and Nepaul in India ; *Crantzia lineata* in the United States from Massachusetts to Texas, in South America from Buenos Ayres to Falkland Islands, and in New Zealand ; § *Phleum alpinum* inhabits the United States, Switzerland, and the Straits of Magellan. ‖

These few cases will suffice to show the strange and apparently capricious distribution of plants. All these are, of course, supposed to be indigenous to the various countries given as their habitats. Now, according to the theory of natural selection and of descent with modification, we must suppose that all plants have descended from parents like themselves, and have not been specially created where they are now found. When we find, therefore, two plants of the same species, or of the same genus closely allied to each other, inhabiting the United States and Europe, or Europe and New Zealand, we must naturally suppose that at some time or other they had descended from the same kind of an ancestor, but that owing to circumstances they have become widely separated. Plants are not like animals, endowed with locomotive organs, and they must therefore have depended on the elements to transport them. To try and discover these modes of transport, then, we shall now proceed.

The winds undoubtedly exercise an immense influence on the distribution of plants. Many seeds are furnished with a pappus or feathery appendage, by means of which they are easily carried along by the wind. Many of these belong to the *Compositæ*, such as the dandelion, the thistles, hieraciums, etc. Others are provided with wings, as in the ash and the maple ; still others with cottony or feathery tails, as in the anemones and clematis. Again, many are so minute as to be visible to the eye only in the form of smoke, and are so numerous as to be almost uncountable. This is especially the case with fungi, mosses,

* Gray's "Manual of Botany," p. 55.

† Humboldt's "Travels," i., p. 115.

‡ Jussieu, *loc. cit.*, p. 712.

§ These five and many others are noticed in an article by Professor Asa Gray, in "Silliman's Journal," second series, vol. xxiii., p. 381, *et seq.*

‖ Humboldt, *loc. cit.*, i., p. 423.

lichens, and ferns. The spores of fungi are so minute as to require a microscope to see them, and so numerous that Fries says he counted in a single specimen of *Reticularia maxima* no less than 10,000,000.* What wonder, then, that with seeds so minute and so numerous these plants should be almost universally distributed? Out of 200 lichens, for instance, brought home to England by the Antarctic Expedition under Sir James Ross, almost every one has been ascertained to be also an inhabitant of the northern hemisphere, and most of them of Europe. It is easy enough to imagine the wind capable of transporting minute spores to immense distances over land and ocean. Many plants not possessing small seeds are carried off bodily by the wind to distant localities. Of these there is the "leap-in-the-field," or the "wind-witch," inhabiting the steppes of southern Russia. "A poor thistle-plant," says Schleiden, "it divides its strength in the formation of numerous dry slender shoots, which spread out on all sides, and are entangled with one another. . . . The domes which it forms upon the turf are often three feet high and sometimes ten to fifteen in circumference, arched over with naked, delicate, thin branches. In the autumn the stem of the plant rots off, and the globe of branches dries up into a ball light as a feather, which is then driven through the air by the autumnal winds over the steppe. Numbers of such balls often fly at once over the plain with such rapidity that no horseman can catch them; now hopping with short, quick springs along the ground, now whirling in great circles round each other, rolling onward in a spirit-like dance over the turf, now caught by an eddy, rising suddenly a hundred feet in the air; often one 'wind-witch' hooks on to another, twenty more join company, and the whole gigantic yet airy mass rolls away before the piping east wind."

Still another plant, the so-called "rose of Jericho," but really one of the *Cruciferæ*, has a similar method of dissemination. Professor Lindley says of it: "At the end of its life, and in consequence of drought, its texture becomes almost woody, its branches curve up into a sort of ball, the valves of its pods are closed, and the plant holds to the soil by nothing but a root without fibers. In this state the wind, always so powerful on plains of sand, tears up the dry ball and rolls it upon the desert. If in the course of its violent transmission the ball is thrown upon a pool of water, the humidity is promptly absorbed by the woody tissue, the branches unfold, and the seed-vessels open; the seeds, which, if they had been dropped upon the dry sand, would never have germinated, sow themselves naturally in the moist soil where they are sure to be developed, and the young plants will be certain of nourishment. Specimens of this curious production are sometimes brought from Palestine, and, although they may be many years old, will, if placed in water, start, as it were, from their slumbers, and assume all the appearance of plants suddenly raised from the dead." The *Sela-*

* Quoted from Lindley by Lyell, "Principles of Geology," vol. ii., p. 390.

ginella convoluta, one of the *Lycopodiaceæ*, and a native of South America, has the same strange habit; for, when the ground where it grows becomes parched and dried up, it curls itself up in a ball, loosens itself from the earth, and is then whirled along over the ground by the wind. When it reaches a place suitable for its growth it uncurls itself, takes root, and flourishes till its new home dries up, when it betakes itself in the same manner to a new locality.

The brief but violent hurricanes of the tropics, which sweep over the land, uprooting trees, overturning houses, and leaving death and desolation behind them, would contribute greatly to a wide dispersion of seeds which would otherwise be but slightly distributed. The tornadoes and cyclones which not infrequently visit the temperate parts of North America would also act a part in this work. An account given by Humboldt shows a possible means of transport over high hills or even mountains. He says "M. Boussingault and Don Mariano de Rivero saw in the middle of the day, about noon, whitish, shining bodies rise from the valley of Caracas, to the summit of the Scilla, five thousand seven hundred and fifty-five feet high, and then sink down toward the neighboring seacoast. The movements continued uninterruptedly for the space of an hour, and the objects, which were at first taken for a flock of small birds, proved to be small agglomerations of straw or blades of grass. Boussingault sent me some of the straws, which were immediately recognized by Professor Kunth for a species of Vilfa (*V. tenacissima*), a grass which, together with Agrostis, is very abundant in the provinces of Caracas and Cumana." *

Let us now turn to another method of transport. As we have seen that, as a general thing, only light seeds, or those with a feathery appendage, are capable of being distributed by the wind, so we shall find that the ones dispersed by means of ocean-currents are of an entirely different character. This must necessarily be the case; for those capable of resisting the action of sea-water for a long time must be inclosed in hard shells. The Gulf Stream, that river of the ocean, is of great use in this work. By its means, seeds of *Entada scandens*, and other plants of the West Indies and tropical America, are annually thrown upon the shores of Ireland, Scotland, Norway, and even as far north as Spitzbergen. That many of these seeds would be capable of germinating, and of continuing to thrive if the climate were suitable, there can be no doubt. A plant of *Guilandina bonduc*, one of the *Leguminosæ*, was raised from a seed cast on the west coast of Ireland. Logs of wood and bodies of Indians, which had been conveyed by ocean-currents from the West Indies, have been cast on the shores of the Azores and Madeira Islands. A *Sapindus saponaria*, the common soap-berry tree of the West Indies, was raised from a seed found on the south shore of one of the Bermuda Islands.† The fact already noticed, of some of the plants on the coast of Brazil and British Guiana being

* "Aspects of Nature," p. 247. † Jones, "Naturalist in the Bermudas," p. 190.

identical with some from the banks of the lower Congo, can be accounted for on the supposition that the seeds were carried from one place to the other by an ocean-current. This becomes still more reasonable when we find that the equatorial current of the Atlantic sweeps up the west coast of Africa until after it has passed the mouth of the Congo, and then crosses the Atlantic to the coast of Brazil. We find, also, that the seeds of all these plants, common to both coasts, are incased in hard coverings, and are the ones of all others capable of resisting the action of the sea-water.

The many islands of the Pacific Ocean have undoubtedly been planted with the cocoanut-palm by ocean-currents. Growing as it does in close proximity to the shore, and thriving on salt and salt water, the nuts could be easily carried out on the ocean by the tide, and then be drifted miles away from the place of growth.

Mr. Darwin found that, out of eighty-seven kinds of seeds, sixty-four germinated after an immersion of twenty-eight days, and a few survived an immersion in salt water of one hundred and thirty-seven days.* He found that ripe hazel-nuts sank immediately, but that when dried they floated for ninety days and then germinated ; an asparagus-plant with ripe berries floated for twenty-three days, and when dry for eighty-five days, and the seeds when planted germinated. Altogether, out of ninety-four plants, eighteen floated for above twenty-eight days, and some of the eighteen for a much longer period.† Estimating the average rate of the several Atlantic currents at thirty-three miles a day, Darwin came to the conclusion that seeds of one tenth of the plants of a flora, after being dried, could be floated across a space of sea nine hundred miles wide, and would then, if driven to a favorable locality, be capable of germination.‡ Seeds have sometimes been found lodged in trees completely protected from contact with the atmosphere. Rocks are known to be lodged in roots of trees, and these, floating on the ocean, are often drifted to islands, and the rocks taken out by the natives. Mr. Darwin thinks that seeds could often effect a lodgment in the crevices with these stones and thus be conveyed long distances.§

Captain Mitchell says he passed through a mass of sea-weed, etc., twelve to fourteen miles across, when three hundred miles from the mouth of the Gambia, which, as Dr. Dickie, who noticed the fact, believed, had come from some part of America within the influence of the Gulf Stream. "Besides algæ," says Mr. Bentham, whom we quote, "the portions of this mass picked up by Captain Mitchell and examined by Dr. Dickie contained, among other substances, fruits, seeds, and 'seedling plants several inches long, all with a pair of cotyledons, roots, and terminal bud, quite fresh.'" ‖ Even if, as is sug-

* Darwin, "Origin of Species," chapter xii , p. 324. † Ibid., p. 325.

‡ Ibid., p. 326. § Ibid., p. 326.

‖ Address by Mr. Bentham before the Linnæan Society. "Nature," vol. vi., p. 131.

gested in the article quoted, the mass had come from some African instead of an American river, it still shows one means by which seeds could be dispersed. Wallace gives further confirmation of this fact. He says: "Rafts of islands are sometimes seen drifting a hundred miles from the mouth of the Ganges, with living trees growing on them, and the Amazon, Orinoco, Mississippi, Congo, and most great rivers produce similar rafts. Spix and Martins declare that they saw at different times, on the Amazon, monkeys, tiger-cats, and squirrels being thus carried down the stream. . . . Admiral Smyth informed Sir Charles Lyell that among the Philippine Islands after a hurricane he met with floating masses of wood with trees growing upon them, so that they were at first mistaken for islands, till it was found that they were rapidly drifting along. . . . The fact of green trees so often having been seen erect on these rafts is most important; for they would act as a sail by which the raft might be impelled in one direction for several days in succession, and thus at last reach a shore to which a current alone could never have carried it."* Now, if such rafts as these were capable of conveying large animals, it would be extremely probable that they would also have on them seeds of many kinds of plants; and, as we shall see hereafter, as the animals themselves often convey unintentionally seeds sticking to their coats, they too would be vehicles for their transportation.

Besides the rafts floated down the rivers, it is very probable that those which overflow their banks periodically, as the Nile, the Ganges, Amazon, Orinoco, and Mississippi, or occasionally as many other rivers do, would transport seeds from plants growing at their sources to hundreds of miles below. Darwin gives the details of an experiment he tried, which illustrates in a remarkable manner the extent to which the mud of rivers and ponds is charged with seeds waiting for a chance to develop. He says: "I took, in February, three tablespoonfuls of mud from three different points beneath water on the edge of a little pond; this mud when dried weighed only six and three fourths ounces. I kept it covered up in my study for six months, pulling up and counting each plant as it grew; the plants were of many kinds, and were altogether five hundred and thirty-seven in number; and yet the viscid mud was all contained in a breakfast-cup!"† There can be no doubt whatever that, after inundations of the land by the rivers, plants spring up in localities where they were unknown before, and the inference is just that the seeds were conveyed by the water.

Birds, too, furnish another and important means of transport. Many fruits having a seed incased in a hard shell are surrounded by a juicy pulp: such are the cherry, plum, mistletoe-berry, hawthorn, etc. All these are eaten by birds which, assimilating the pulp, cast the stones in their excrement. The parasitic mistletoe has no way of

* Wallace "Geographical Distribution of Animals," vol. i., pp. 14, 15.

† "Origin of Species," pp. 345, 346.

being disseminated but by the birds; these, swallowing the berries, use the pulp and cast the stone on branches of trees with bark suitable for their growth, where they take root and flourish. That the vitality of many seeds is not at all impaired by this process of passing through the stomachs of birds has been incontestably proved. Indeed, it is said that, when the farmers of some parts of England are desirous of making a hedge of hawthorn (*Cratægus oxyocantha*) grow in a short time, they feed the haws to their turkeys; the stones are rejected in the excrement, and when collected and planted a whole year is gained in the growth of the plant.* It is also known by experiments that seeds in the crops of birds are not always injured; for the crop does not secrete gastric juice, and, as it is often not until twelve or eighteen hours after the act of swallowing that the food passes into the stomach, birds which are capable of rapid and prolonged flight could pass over a large tract of land or of sea. Passenger pigeons have been killed in the neighborhood of New York with their crops still full of rice collected by them in the rice-fields of Georgia and Carolina. As it is positively asserted that they will decompose food in less than twelve hours, they must have traveled three or four hundred miles in less than six hours.† This is by no means an extravagant estimate, but rather under the mark. Falcons are reckoned the swiftest of all birds. It is recorded that one, sent from the Canaries to Spain, returned to the Peak of Teneriffe in six hours, a distance of about seven hundred and eighty miles.‡ Seeds of wheat, oats, millet, Canary hemp, clover, and beet, germinated after being twelve to twenty-one hours in the stomach of birds of prey; and two seeds of beet germinated after having been thus retained for two days and fourteen hours.§ Seeds taken out of the crop of a pigeon, which had floated on artificial sea-water for thirty days, nearly all germinated.‖ Hawks are always on the lookout for weary birds, those which have made long journeys; and pigeons and ducks coming from over the sea, as they are often known to do, would be easily caught and devoured by these birds. The bodies are devoured, and the contents of the crop perhaps scattered in a locality favorable to the development of any seeds which might be contained therein. Darwin forced seeds of various kinds into the stomachs of dead fish which were then given to eagles, storks, and pelicans. These birds, after an interval of many hours, passed the seeds in their excrement, or else rejected them in pellets, and several of them were then capable of germination. Some kinds, however, were invariably killed by the process.¶

Besides this method there is still another. This is by means of dirt or dried mud adhering to the legs and feet of birds. Still drawing on that cyclopædia of learning, Darwin's "Origin of Species," we read:**

* Lyell, "Principles of Geology," vol. ii., p. 398.
† Audubon.
‡ Figuier, "Reptiles and Birds," p. 193.
§ Darwin, *loc. cit.*, p. 327.
‖ Darwin, p. 326.
¶ Darwin, ibid., p. 327.
** P. 328.

"Although the beaks and feet of birds are generally clean, earth sometimes adheres to them. In one case I removed sixty-one grains, and in another case twenty-two grains, of dry argillaceous earth from the foot of a partridge, and in the earth there was a pebble as large as the seed of a vetch. Here is a better case: the leg of a woodcock was sent me by a friend, with a little cake of dry earth attached to the shank weighing only nine grains, and this contained a seed of the toad-rush (*Juncus bufonis*), which germinated and flowered. . . . Professor Newton sent me the leg of a red-legged partridge (*Caccabis rufa*), which had been wounded and could not fly, with a ball of earth adhering to it weighing six and a half ounces. The earth had been kept for three years, but, when broken, watered, and placed under a bell-glass, no less than eighty-two plants sprang from it; these consisted of twelve monocotyledons, including the common oat and at least one kind of grass, and of seventy dicotyledons which consisted, judging from the young leaves, of at least three distinct species. With such facts before us, can we doubt that the many birds which are annually blown by gales across great spaces of ocean, and which annually migrate—for instance, the millions of quail across the Mediterranean—must occasionally transport a few seeds in dirt adhering to their feet or beaks?"

So, too, animals perform a part in this grand work. Many seeds are furnished with hooks or prickles of various kinds, which enable them to cling to the hair and wool of animals. Take Lyell's illustration of the hunted deer as an instance of how this work could be performed: "A deer has strayed from the herd when browsing on some rich pasture, when suddenly he is alarmed by the approach of his foe. He instantly takes to flight, darting through many a thicket and swimming across many a river and lake. The seeds of the herbs and shrubs which have adhered to his smoking flanks, and even many a thorny spray which has been torn off and fixed itself in his hairy coat, are brushed off again in other thickets and copses. Even on the spot where the victim is devoured, many of the seeds which he has swallowed immediately before the chase may be left on the ground uninjured and ready to spring up in a new soil." *

As Lyell remarks in this quotation, many of the seeds which animals swallow may pass through the stomach and still retain vitality enough to sprout after being left on the ground. Instances of this can be seen in almost every barnyard, where the grains of corn and oats dropped in the excrement of cows and horses sprout, if not picked up by the barnyard fowls. Farmers know well, too, that a field manured with fresh manure is likely to produce not a few weeds along with its legitimate crop.

Even such insignificant forms of life as insects may and do perform a part in the transportation of seeds. From a small packet of

* "Principles of Geology," vol. ii., p. 397.

locusts' dung received from South Africa, Mr. Darwin extracted and raised seeds of seven grass-plants, which belonged to two species of two genera.* These locusts are sometimes found as far as three hundred and seventy miles from land; and an account is given of a cloud which hovered round the Island of Madeira for three days, and then disappeared without alighting. Such a cloud as this would undoubtedly be capable of introducing the seeds of foreign plants into insulated localities. The immense number of grasshoppers which have devastated the plains of Kansas and Nebraska would in the same way be the means of introducing seeds of foreign plants.

There is still another method which has been at times used by Nature for the distribution of plants, and that is by means of the alternation of hot and cold epochs, commonly known as glacial periods. Now, it has been demonstrated beyond all doubt that at one period of the earth's history the Arctic regions were much warmer than they are at present; this is proved by the occurrence in the geological formations of these high northern latitudes of plants in a fossilized state, which were utterly incapable of existing in any latitude where the climate was colder than it is now in our temperate regions. Reasoning from analogy and our knowledge of the present distribution of Arctic plants, it would not be improbable that the plants inhabiting the lands of the pole were the same on all longitudes of the Arctic Circle. Let us, then, suppose the glacial period to commence in these warm lands. Each plant, following to a greater or less degree the longitudinal line on which it grew, would be slowly but steadily driven by the increasing cold to take refuge in warmer and more southern stations. The cold, in the course of years following them slowly up, would compel them to keep continuing their journey southward until such time as the maximum of cold had been reached. Then, if, as it is reasonable to suppose, many of these plants had migrated on the longitudinal line upon which they had lived directly southward, we would find that the plants, which at the Arctic Circle, or beyond, had lived in close proximity to each other, would be separated when they reached the temperate zone by hundreds of miles.

In the general journey southward, the plants of the mountains would descend to the plains and mingle with those of the far north. Then the climate commences to moderate; and, as the mountains of ice and snow retire to their original homes in the north, many of the plants would keep company with the cold and return, but many others, encountering mountains in their paths, would find the climate cold enough for their growth, and would be left there in isolation while their nearest relatives would be separated from them by hundreds of miles of country.

Now would come the cold period of the southern hemisphere and drive the plants inhabiting the country there northward, and these again

* "Origin of Species," p. 327

would retire south or up the mountains of the tropics when the cold moderated and the warm season again commenced. Then another season of glacial cold begins in the north. The plants which had before been left on the mountains would stand a good chance of being driven by the increasing cold to the plains, and still farther south, even perhaps across the equator into the southern hemisphere, and when the cold again decreased would retire to the fastnesses of the mountains.

If we accept this view of the influence of glacial periods on the vegetable kingdom, we shall see that many of the apparently anomalous cases of distribution mentioned in the first part of this article are explained. We can easily see why some of the inhabitants of the temperate and arctic zones of the northern are represented in corresponding zones in the southern hemisphere; it is easily explained why identical species of mosses are found in Lapland, on mountains of Jamaica, and the Peak of Teneriffe; why plants of the Pyrenees are identical with those of the Arctic regions; why species are found on the White Mountains of New Hampshire and in Greenland, but not in the intervening region, and why species are found in northern Europe and America, in Chili and New Zealand. This theory of alternate hot and cold periods is as yet the only one by means of which these cases can be explained.

Such, then, are some of the natural methods for the distribution of plants; the air, the water, beasts, birds, and fishes, as we have shown, all perform their several offices; but there is still another method of transport of which nothing has been said, and this is the part which man plays in the grand work. This is by no means insignificant, and can be shown in many ways. Out of the 2,582 species given in Gray's "Manual of Botany", there are 305 introduced species, and, of these, 278, all but 27, were imported from Europe. Nothing shows more strikingly man's influence than this fact, which is further corroborated by the assertion that the greater part of the plants naturalized at the Cape of Good Hope and in Australia are of European origin.* With the great increase of facilities for travel, on land and on sea, with the extension of commerce to all quarters of the globe, and with the settlement and consequent clearing off of formerly unoccupied lands, we find both the fauna and flora of many countries greatly modified. There can be no more striking example of this influence of mankind then that shown in the Island of St. Helena. "When St. Helena was discovered, about the year 1506," says Lyell,† "it was entirely covered with forests, the trees drooping over the tremendous precipices that overhang the sea. Now, says Dr. Hooker, all is changed; fully five sixths of the island is entirely barren, and by far the greater part of the vegetation which exists, whether herbs, shrubs, or trees, consists of introduced European, American, African, and Australian plants, which propagated themselves with such rapidity that the native plants could not compete with them.

* Lyell, "Principles of Geology," vol. ii., p. 402. † Lyell, ibid., vol. ii., p. 457.

These exotic species, together with the goats, which, being carried to the island, destroyed the forests by devouring all the young plants, are supposed to have utterly annihilated about one hundred peculiar and indigenous species, all record of which is lost to science, except those of which specimens were collected by the late Dr. Burchell, and are now in the herbarium at Kew."

Dr. Burchell himself sowed on a point of this island, in 1845, seeds of *Chenopodium ambrosioides*, and it multiplied so rapidly that, in four years, it became one of the commonest weeds on the island, and has maintained its ground ever since.* *Erigeron Canadense*, introduced from America into Europe, has become there one of the commonest weeds, and is now naturalized all over the country.† *Datura stramonium*, now known over almost all Europe and North America, was introduced from the East Indies by the gypsies, who used the seeds as a medicine.‡ *Œnothera biennis*, introduced from America into Europe by the French, on account of its esculent roots, in 1674, has since spread so that it now grows wild in almost every country in Europe, in the hedges and about the villages. § Our agave and *Opuntia vulgaris* have both been so extensively naturalized in the south of Europe, and they form so conspicuous a feature in the landscape that they have been noticed by many travelers and recorded as indigenous.‖ *Anacharis Canadensis* (water-weed) was introduced into England in 1841, and spread so rapidly that it has become a nuisance by impeding navigation in rivers and canals, in spite of efforts made to eradicate it. ¶ Strange to say, nothing of the kind is complained of here in its native country. In the district of Canterbury, New Zealand, Mr. Locke Travers, writing in 1863, says *Polygonum aviculare* (common dock) and sow-thistle (*Sonchus*) grow luxuriantly; the water-cress increases in the still waters and rivers so rapidly as to threaten to choke them up entirely, and to put the inhabitants to the expense of £300 annually to keep open a single stream. Stems of this cress have been measured twelve feet long and three fourths of an inch in diameter. "In some mountain districts the white clover is displacing the native grasses; and foreign trees, such as poplars and willows, and gum-trees of Australia, are growing rapidly." **

All these plants have been introduced into the different countries by man's agency. Numbers of seeds are no doubt conveyed in the raw-hides taken from one country to another. De Candolle says he found numbers of exotic plants growing in the vicinity of a place in the south of France where the hides brought by ships were washed and cleaned. Ballast-heaps near large seaport towns are favorite places of resort for resident botanists, who there often reap rich har-

* Lyell, "Principles of Geology," ii., p. 402.

† Jussieu, "Elementary Botany," p. 717.

‡ Willd., "Botany," p. 419.

§ Willd., ibid., p. 420.

‖ Jussieu, ibid., p. 717.

¶ Lyell, *loc. cit.*, ii., pp. 401, 402.

** Lyell, *loc. cit.*, ii., p. 458.

vests of introduced plants. To show their number, witness the long lists given by Mr. Isaac Martindale of those found near Philadelphia, and of Mr. Charles Mohr, of Alabama, of those found at Pensacola, New Orleans, and other places. Wars, too, are the means of spreading plants. It is said that great numbers of new plants have been found in France, in the vicinity of places where the Germans had brought forage for their horses and stacked it. Of course, many plants introduced in this way do not thrive longer than a year or two, but some of them no doubt take up their residence permanently. Man's propensity to seek out attractive plants in far-off countries, and to transplant them to his home to make his garden attractive, has been the means of the naturalization of many species. These have ample opportunity to escape into the surrounding country, and with favorable conditions to spread extensively in all directions. Seeds of many weeds are mixed with the wheat and other grains which man carries with him wherever he goes, and plants wherever he may happen to settle. Railroads are efficient agents in the work. Seeds are lodged on the platforms of the cars, are carried along by the wind created by the passing trains, and in many other ways are distributed along the track. There is an instance of the work of the railroad in the east end of Cincinnati, near Fulton, on the Little Miami Railroad. For the last two or three years there have been growing great numbers of *Euphorbia marginata*, a plant which is a native of the plains of Kansas, and which is slowly but surely working its way toward the East by means of the railroads. Eastern plants, which a number of years ago were wanted in exchange with the West, are now naturalized in the West, and *vice versa*.

HYSTERIA AND DEMONISM.*

A STUDY IN MORBID PSYCHOLOGY.

By CHARLES RICHET.

III.

THE mysterious problem of somnambulism is closely connected with the study of the demoniac affection. It is necessary to enter into some details on this subject, for we should not be able to comprehend the nature of certain epidemics of the middle ages if we were not acquainted with the different symptoms of the sleep called magnetic. Moreover, the effrontery of charlatans has mixed up so many absurdities with the real facts appertaining to this malady that it is hard for persons who have not made a special study of it to preserve a just mean between the credulity that admits

* Translated from the "Revue des Deux Mondes" by W. H. Larrabee.

everything, however absurd, and the skepticism that admits nothing, not even that which is true. A German physician named Mesmer arrived in Paris in 1778. Marvelous stories were told of him. He had, several years before, published a curious, somewhat mystic book, in which he affirmed the existence of a universal fluid, diffused in all nature, and competent to pass into the body of man. He had not yet become celebrated, but Paris, then as now a center and focus of opinion, speedily gave him a brilliant renown. He established himself in quarters in the Place Vendôme, proceeded to teach his theory of the magnetic fluid, and soon gained some pupils, among whom was a doctor named Deslon, who became associated with him. Disputes arose in course of time between the two magnetizers. Deslon was reprimanded by the faculty and excluded from its association as a charlatan.

Throngs of clients came to Mesmer. Everybody wanted to be magnetized. Mesmer could not attend to all the applicants, and employed an assistant who made the passes in his place. This was not enough, and Mesmer then invented the famous *baquet*, or magnetizing chest, by means of which thirty or forty persons could be magnetized at once. The subjects were introduced together into a large room, in the middle of which was an oaken chest, containing jars, connected with each other by metallic rods. This apparatus was inclosed in another chest, from which projected handles of iron. These were taken hold of by the persons desiring to be put under the magnetic influence. A complete silence is prevailing, when suddenly sounds of melody are heard proceeding from an adjoining room. Then, under the influence of a sympathetic emotion or of irritation, a kind of nervous excitation is communicated from one to another among all those who are assisting; curious symptoms appear among the magnetized persons. First, there is languor, then drowsiness; shortly afterward, a frantic agitation, which is succeeded by contortions and convulsions. The silence is broken only by the muffled tones of the organ and the groans of the patients as they fall seized with the convulsive attack. It is easy to conceive how well-suited are such scenes to develop nervous crises in persons who are predisposed to them. The infatuation became general in Paris, and there were showers of apologies, pamphlets, songs, and caricatures on Mesmerism. It was all the fashion; the house in the Place Vendôme became too small, and Mesmer bought the Hôtel de la Bullion, Place de la Bourse. In the course of five years, from 1779 to 1784, he magnetized eight thousand persons. But the Tarpeian Rock is near the Capitol; discredit rapidly followed the general favor. Mesmer was ridiculed at the opera, was abandoned by his disciples whom he had lived upon, was insulted in the streets of Paris, and had at last, in 1785, to take refuge in Switzerland.

The learned societies were not indifferent to the pretensions of animal magnetism. The Academy of Sciences appointed a committee, of whom Bailly (that unfortunate Bailly who was to perish on the scaffold some years later) was the reporter, to investigate them. Its conclusion was that the pretended magnetic fluid did not exist, and that the experiments and observations of Mesmer were based on nothing real. One of the members of the committee, the celebrated Laurent de Jussieu, declined to sign this report, and in a memorial, which had a considerable support of public opinion, admitted that there was a portion of truth in Mesmerism, which ought to be discovered and extracted from the juggleries, unworthy the attention of scientific men, in which it was buried.

Mesmer was not, in fact, the creator of the theory of animal magnetism. If the Marquis Armand de Puységur had not repeated his experiments, the art would not have existed, and the subjects of the *baquet* of Mesmer would have been put in the same class with the convulsionists of St. Médard. Puységur cured several sick at Poissons by touching them; then others, and still others. He gathered disciples, he wrote numerous papers, he indicated the processes that should be employed to put a subject to sleep, he described the phases of induced somnambulism, between 1785 and 1825. Experimentists, whose good faith, if not their good sense, could not be suspected, everywhere repeated his experiments; physicians and men of science occupied themselves with them and confirmed them in part. Petetin, Deleuze, Dupotet, Husson, Braid, and many other persons whose names are less familiar, developed and interpreted his ideas. Through their confused work the fact has been brought up into clear evidence, from among the absurd errors and hardly imaginable follies in which it was buried, that a nervous affection of a peculiar nature may be induced among subjects who are more or less predisposed to it. At present, all enlightened physicians recognize that somnambulism exists with symptoms which are always identical, and that it has a right to be recognized as a special form of disease. We shall try to tell in a few words what must be believed about it, remarking that we do not speak of it from hearsay, but according to facts which we have ourselves observed.

The processes by the aid of which somnambulism is induced are irregular and empirical. If the subjects are predisposed and habituated, by having had previous attacks, to be affected by that neurotic disorder, a slight disturbance of the nervous system, sometimes the most insignificant in the world, is enough. A subject who has been frequently put to sleep may be magnetized in less than half a minute. But, in dealing with a person who has never before been put under magnetic influence, the rules of the magnetizers must be followed, however ridiculous they may seem. The operator must set himself opposite the face of the subject, make a few passes with his hands before his forehead, and look at him fixedly. Very often no result will be obtained at the first sitting; but the operator will learn by experience not to be discouraged by an apparent want of success. He should make another trial on the next day, and again on the next; but, if after about the third sitting no result is obtained, it will be time to give up the subject as intractable. Such cases are, however, rare, and generally sleep is brought on at the third sitting, if not before.

The first sign observed is a kind of torpor. The countenance loses its mobility, and becomes dull and inexpressive. The subject feels a heaviness in the limbs, and a singular torpidity which prevents him from making the least exertion. He has vague sensations of heat, cold, pricklings, and, while his hands continue motionless, he suffers jerkings of the tendons and fibrillar contractions in the muscles. His eyelids become heavy and close. With many efforts he vainly opens them, only to shut them again; the time comes at last when it is impossible to make them move. A curious spectacle is then presented of a struggle between sleepiness and the will to resist it. The will has to yield at last; the head falls stupidly on the chair; the arms become motionless, keeping the attitude they had; the face is fixed as a lifeless mask, expressing no internal feeling; the closed eyelids are moved by a few convulsive tremors; the breathing is quiet; the heart beats slowly and regularly. We might at first believe that this induced sleep is identical with ordinary sleep, but it is nothing like it, and is characterized by very different symptoms.

The fact that insensibility exists in both permits us to liken induced somnambulism in a certain degree with the demoniac attack. We may prick the skin of magnetized persons with a needle, tickle their nostrils and lips with a feather, without provoking any sign from them. Unfortunately, while anæsthesia is complete in some subjects, it is wholly wanting in others, so that we can not perceive in it a single essential characteristic symptom which will permit us to judge whether the sleep of the subject is real or assumed. For this reason, some of the physicians who have employed this criterion have been led to deny the reality of somnambulism; for, instead of finding insensibility, as they had expected, they have perceived that each pricking excited a painful feeling. In certain cases even, sensibility, instead of being diminished, is exaggerated to such a point that the slightest contact excites pain. In a word, individual differences forbid us to adduce an absolute law, and there are so many exceptions that we can not speak of a rule.

The person who is put to sleep is conscious of his condition, and we may be sure that he is really asleep if he says that he is when we ask him about it. If we then inquire as to the sensations he experiences, we will generally be assured that this sleep is quite pleasant. Many of the patients whom I have put to sleep at the Hospital B—— assured me that their pains had disappeared. They also wished to remain asleep for a long time, knowing that the wakening to their normal life would be at the same time a wakening to pain. I add that, if the condition of somnambulism is not disagreeable, it is also without danger. I do not know that any accidents, either grave or light, have been noticed as consequences of it; and it is even possible that in certain cases it appeases the over-excited nervous system; but on this matter it is necessary to speak with much reserve, for decisive facts bearing on it have not yet been collected.

Let us now analyze the psychological phenomena of somnambulism. We all know what a dream is: when, tired with the labors of the day, we give up to sleep, our thoughts become confused and floating; the attention can no longer be held fixed upon any definite object; we gradually lose consciousness of the exterior world, and strange forms, the reality of which is in our conception only, impose themselves upon us. They pass and repass with marvelous facility, changing at every instant, and bewildering us with a moving and fantastic train. There are human faces with the forms of beasts, wonderful monsters, gardens, palaces, persons who had disappeared long ago, and who we thought had passed from memory. All this is in motion and passes before us, and the mind assists as a powerless spectator at a representation of which it has itself formed all the pieces. The imagination luxuriates in full license, for it is freed from the liability of being interrupted as in real scenes by the intrusion of foreign objects, forcing themselves upon attention at every instant to excite precise sensations and recall us to reality. A fact which marks the difference between somnambulism and ordinary sleep is that the dream, which is only spontaneous in ordinary sleep, may be provoked in somnambulism. It would be very hard, for example, to make a man who is sleeping quietly in his bed dream of a lion. If we should say to him aloud, "Look at the lion!" one of two things would happen: he would not hear us, or he would wake up; but in either case he would not dream of a lion. On the other hand, I once said to one of my friends whom I had put into the condition of somnambulism, "Look at that lion!" He started at once, and his face expressed fright; "He is coming," he said, "he is coming nearer, let us run away—quick, quick!" and he almost had a nervous crisis under the influence of his terror.

It is well known that the magnetizers by profession pretend to cause their subjects to travel (in mind) through space, and to make them spectators at distant scenes. This is true. But it is not true, it is rather absolutely false, that these dreams partake of the reality, that the visions bear any relation to the truth. They are pure imaginations, and are neither more nor less fanciful than all the vague conceptions which are forged by every person during sleep. By way of example, I will relate a story of one of the somnambulist patients in the Hospital B——. I said to her: "Come with me; we will go away and travel." She then described in succession the places we had to pass; the corridors of the hospital, the streets we had to go through to get to the railroad station; she arrived at the station, and, as she was acquainted with all of these places, she pointed out with sufficient exactness the details of the spots which her imagination and memory, equally over-excited, represented to her under a real form. She could be instantaneously transported to a distant place she was not acquainted with, the Lake of Como, for example, or the frozen regions of the north pole. Her imagination, left to itself, indulged in descriptions which were not wanting in attractiveness, and were always interesting by their apparent precision; but no greater mistake could be made than to accord to these chimerical conceptions the honor of being truths. Having one day put a friend to sleep, I undertook to send him on a voyage by balloon to the moon. I felt a real surprise when he said to me delightedly, "Oh! oh! what is that great white ball below us?" His imagination represented the earth to him. He saw animals of fantastic shapes, and, when I told him we must take some of them to the earth, he objected: "Why," said he, "you do not know how we are going to get down, and you want to charge yourself with those great animals? I thank you, I will let you do it, and shall certainly not trouble myself with them." He was, nevertheless, aware of the strange character of his visions, and said: "What a fine story we could tell about them; but, unfortunately, they would not believe us!"

The reason of somnambulists is perhaps perverted, but their intelligence is certainly not diminished. It is over-excited and exceedingly active. Varied and engaging conversations may be held with a subject who has been put to sleep. The language of uneducated women, for example, becomes almost elegant, with ingenious turnings of phraseology, and ideas that do not lack in elevation. Without assuming in the slightest degree that they can divine the thought of their interlocutors, it may be remarked that they seem to have acquired a faculty of penetration which enables them to comprehend what has been only half said. The most striking characteristic they present is the wonderful vivacity of their feelings. Thus, nothing is more easy than to make them cry; it is enough only to mention a sad subject to them, when, even if the story which is told them interests them only a little, they will sigh, shed plenty of tears, and sob. In many cases a nervous excitement will be provoked by such narrations, which must be calmed as quickly as possible by causing the subjects to imagine agreeable pictures. This sensitiveness to the troubles of another, these exaggerated compassions, may perhaps be compared to what persons in the first stages of intoxication feel. Sometimes, also, feelings of joy and admiration are pushed to an excess; poetry and music especially will produce a real ecstasy; and it is impossible to forget the spectacle after having once witnessed the power of mimicry which the subjects display. The manifestations of admiration are frequently crossed by childish angers, inexplicable antipathies, and sympathies still more strange than the others. Sometimes the subjects jest, and not without wit; they laugh at the pleasantries they say or commit;

and their laughter, like their weeping, often ends in a remarkable excess of excitement.

One of the most interesting phenomena of somnambulism was described thirty years ago by the Englishman Braid. If we put the limbs of a magnetized person into a particular position or the body into a particular attitude, the feelings which correspond with the position or attitude will be called up by it. Thus, if we thrust out the fists of a subject, his features will immediately take on the expression of rage or menace. If we join his hands in the attitude of prayer, he will fall upon his knees, and his features will give the appearance of one who is engaged in supplication. His face thus assumes the true expression of the passions; and no painter, no sculptor, has succeeded in representing terror, disgust, contempt, wrath, amorous tenderness, religious ecstasy, with as much likeness to the life as do somnambulists, even the least intelligent ones, when we excite those feelings in them. This is because the mind, concentrated upon itself, is not disturbed by any of the external causes of excitement which continually and generally without our knowledge impose a restraint upon our internal feelings. The anger of a somnambulist is a typical anger, ideal, and his countenance will wear the expression of it in a high degree according as the feeling that animates him is strong and unmixed.

The magnetizers make wonderful pretensions. They declare that all these facts are of the earth earthy, and, assuming to rise away above their plane, they have imagined that the intelligence of the somnambulists is capable of pulling aside the curtains from the future, of penetrating the mystery of things that are and will be. They have talked of clairvoyance as a power of seeing without the aid of the eyes, as for example of reading a shut book, of hearing without the aid of the ears, of being present at a conversation which is taking place at the same moment at the other end of the world. Justice must be done to these fables; there is nothing supernatural in somnambulism, any more than in the demoniac attack, and no well-demonstrated fact has ever permitted us to conclude that such a thing as double sight or clairvoyance exists. The somnambulists who are exhibited in the theatres and at fairs, as, for example, the celebrated Lucille who was shown several years ago, are really put to sleep, but the condition of genuine somnambulism into which they have fallen does not exclude them from the power of simulating clairvoyance. They are aware of what they are doing, and they know very well that it is their business to divine the future. They are anæsthetic, and we may pinch them, prick them, burn them, without exciting a painful sensation. The phenomena of catalepsy may also be very easily produced upon them. Their intelligence, over-excited by their nervous affections, enables them to find ingenious answers. In a word, the clairvoyants of the theatres and fairs are really asleep, but they are not diviners, only sick persons, and their true place would be in a hospital for the insane.

The moment of awakening presents curious features; most frequently, somnambulists on waking are in a deep stupefaction; they look at the persons around them without being able to believe the truth of what they are told; they have preserved no recollection of what has passed while they were in sleep; and, since, in a psychological point of view, time is measured only by the remembrance of ideas, they have wholly lost the notion of time. The moment when they were put to sleep is confounded with the moment of waking. It also happens that what took place during sleep returns to their memory when they are newly put to sleep; and this probably furnishes an explanation of the doubling of the personality of which some of the magnetizers speak. It is what we may call the collection of our memories that constitutes the I; and, when we find that certain memories are reserved for a special physical condition, we almost have a right to say that the personality is doubled, because it recalls a whole series of acts in sleep of which it is absolutely ignorant in the waking state.

The hysterical patients of the Salpêtrière can be put to sleep with the greatest ease. Anything that will powerfully excite the senses is sufficient to induce the somnambulic paroxysm—as, for instance, the flash of the electric light, or the metallic, harsh noise produced by suddenly striking the tomtom or the Chinese gong. Sleep comes right on, with such rapidity that the subjects do not even preserve the memory of the shock which has for a time destroyed the consciousness of their existence. If the gong is sounded while the patients are together in one of the courts of the hospital, the greater part of them will stop short with their eyes open and their limbs fixed in an attitude indicating stupefaction mingled with fright. This condition of sleep provoked by a violent shock to the nerves is not at all identical with the somnambulism which is induced by passes. The sleep is deeper, more animal, and, we might say, more pathological; the functions of the nervous system and the muscular system are more gravely disturbed. Insensibility is complete, and the patient, if some one does not wake her up, will remain for hours as if she were annihilated in a sleep without a dream. If the eyes are open, there is catalepsy—that is, the muscles will retain indefinitely the position that has been given them. If, for example, the arm has been lifted into the air and put into an unnatural position, it will continue raised in the attitude that has been imposed upon it. If, on the contrary, the eyes are closed, other phenomena will be brought out. The nerves will have become extremely excitable, so that any muscle may be made to contract by merely placing the finger across the nerve which produces that action. The muscles themselves are also extremely excitable, so that we may make them contract and even draw up by simply touching them. If we insist, we can cause them to draw up closely, and make the fingers double up upon the hand, and the forearm upon the arm. If we waken the patient without having taken the pains to relax the muscular contraction, it will persist for a long time, and it will be almost impossible to put an end to it until a new paroxysm of somnambulism has been brought on.

The symptoms of this curious malady do not appear only among women and persons afflicted with hysteria; they are also observed, though more rarely, among young persons and with aged men. Not only do they arise when they are provoked; they frequently appear spontaneously, without any effort to induce them. Natural somnambulism, which in former times greatly excited the curiosity of medical men, is now a well-described affection. New examples of it are of daily occurrence. Persons subject to it will get up in the middle of the night, dress themselves, start to go out and attend to their business. Their eyes are sometimes shut, sometimes wide open, but they have no real sight. Their vision is all interior, but serves them so good a purpose that they are able to find their way through the furniture scattered around the room without a light. Memory is the unerring guide of their movements. They can read mentally the book which they open, and perform similar actions to those they would be engaged in if they were awake—as, for example, those of swimming, running, writing, and handling arms. If they are suddenly wakened, they will be stupefied at finding themselves up and dressed when they had supposed that were reposing quietly in their beds. Instead of seeking for something marvelous in these phenomena, would it not be better to satisfy ourselves that they resemble those that we may observe in ordinary sleep? The mother, bending over the pillow of her sick child, is able by means of her caresses and soft words to calm the spirit which is distressed by the terrific visions of the nightmare, and make the child sleep more sweetly without waking it. Sometimes, when we are half-awake, half-asleep, as in the evening, for instance, when sleep weighs upon us, or in the morning, when it has not quite left us, we act and speak without being quite aware of what we are doing or saying. This is a light degree of somnambulism; and, if we will study ourselves with a little care, we will recognize that, at the beginning or at the end of sleep, the complete, exact consciousness of our actions and our thoughts escapes us. There is, then, a series of insensible transitions between the common general sleep of the world and the singular sleep, more wonderful in appearance than in reality, of the somnambulists and hysterical persons.

Notwithstanding a whole class of positive facts exist, proved and easy to verify, there are still some medical men who do not admit the reality of them, and are ready to smile at the mention of somnambulism as if a colossal deception were spoken of. In their view, all the cases of this condition of sleep are nothing but comedies skillfully played before too simple spectators by nervous women who have been made fanatical by delirium. They believe this because they have been satisfied with witnessing the acrobatic scenes which the magnetizers and the professional somnambulists offer as a spectacle to the credulity of the public. If they had observed for themselves, if they had handled with their own hands and seen with their own eyes the phenomena of which they deny the existence, I do not doubt that they would have had an entirely different opinion. Is it possible to suppose that all the somnambulists that have appeared during the last hundred years would have feigned the same symptoms just to conform themselves to the fancies of the little peasant Victor, the first case of the Marquis de Puységur? How, by what strange divination, can they all exhibit the same signs of the same nervous affection? Would it not be a really marvelous fact if a deception carried on for a hundred years through all Europe should everywhere and always present the same features, and if all the physicians, all the men of science who had devoted themselves to the study of it, should have become victims to the same unexplainable imposture?

Somnambulism must, then, be regarded as a veritable disease, the symptoms of which are as well described as those of hysteria and epilepsy. The only remarkable and obscure side of the study of it is that the nervous affection can be induced by exterior manœuvres, the method of the action of which escapes us. Our ignorance of the cause of the phenomenon furnishes us no reason for denying its existence. Hereafter, possibly in the course of a few years, we may arrive at an exact acquaintance, not with the symptoms, which are quite well known now, but with the physiological causes of somnambulism. We have reason to hope that the empirical processes which are at present employed will be replaced by scientific methods, the trustworthiness of which no one will be able to put in doubt, and the efficacy of which will endure every test.

We have seen, in the course of these investigations, that there are diseases which, without producing insanity properly so called, deeply disturb the functions of the understanding. The disturbances they occasion are certainly wonderful, and calculated to excite surprise; but we are justified in affirming that they are subject to natural laws, and not to the fancy of the seven million four hundred and five thousand nine hundred and twenty-six devils of hell. This was not the opinion of the judges of the seventeenth century; and it is not one of the least of the benefits that science has conferred upon us, that it has affirmed and proved the innocence of the miserable sufferers from these diseases who were formerly consigned to the stake.

NOTES ON A FEW OF OUR BIRDS.

By HARRY MERRILL.

MUCH has been said and written in regard to the fact that birds temporarily change their habits and customs, and adapt themselves to surrounding circumstances so as to meet their immediate wants and necessities; and these changes are by no means rare, but occur whenever anything is interposed which may conflict with their usual methods of practice. In some cases these habits have been perpetuated, and have become the established custom of a number of species. Our martins and chimney-swallows have almost entirely deserted their original quarters in hollow trees for those that have been furnished by the advent of man. Some sea-birds, that in Labrador build nests and raise their young in the usual way, in the south abandon their eggs to the sand and sun, which perform the duties of a parent in the most acceptable manner. It is noticed that birds which usually build on the ground, particularly sparrows, frequently build in bushes or even in low trees. This is very often the case in pastures where the nest and eggs would be liable to be destroyed by being trodden on by cattle or sheep; in such a situation I have found a nest of the song-sparrow at a height of six feet.

During the past few years I have met with many instances where birds have so changed their habits; and the purple grackle or crow-blackbird has furnished several examples of this kind. These birds are quite common, and rule with undisputed sway over the groves in which they dwell. One of these nesting-places is situated on the banks of the Kenduskeag River in Maine, in a most beautiful spot, where steep ledges rise abruptly from the water's edge, and are covered with a rich growth of pine and cedar, together with wild flowers and climbing plants. Here these birds for many years have built their nests, a single tree often containing several of them; they are very bulky affairs, composed of mud, weeds, and similar materials, and lined with hay.

Peace and prosperity dwelt in this little colony until a few years ago, when the destroyer, man—or rather the father of the man, the boy—commenced to collect birds' eggs; then this spot offered a rare field for his depredations, and one that was not overlooked, so that in a short time many were robbed of home and its treasures, and driven from their ancestral grove. Thereupon, large numbers of the birds proceeded to a lumber-yard situated on the river a short distance below, and, seeking there that peace which the grove failed to give, commenced building their nests in the huge piles of boards which lined the water's edge, and in this peculiar situation they began anew the battle of life and reared their young.

In 1874 I found a pair of these birds occupying a woodpecker's deserted hole, and every new year finds them in their old abode, in spite of the fact that they were once robbed of all their eggs, showing very plainly how attached they become to their old haunts, and that even to a blackbird "there is no place like home." Audubon says that in the South the crow-blackbird frequently makes use of holes in trees, where a few dry weeds and feathers are collected on which the female deposits her eggs; Burroughs, also, notices that this bird, "seized with a fit of indolence, drops its eggs in the cavity of a decayed branch." In New England, however, this is not often the case, and in the instance mentioned indolence was clearly not the cause of their selecting this residence, for the nest was constructed exactly similar to those built in trees. I also found a nest of this species in a low marsh which was occupied by red-winged blackbirds as a nesting-place. This nest was built in low bushes about eighteen inches above the water, and was in structure like the redwing's nests among which it was placed, there being *no mud* used in the construction. This case, so far as I can learn, stands alone as a peculiar instance of adaptation to surroundings as exhibited by these birds.

Every one in New England probably knows the night-hawk, though persons generally are but little interested in it, and very few indeed become well acquainted with its habits. This may be partly due to the fact that it has no song to recommend it, but is principally owing to its habit of remaining perched along some limb during the daytime, when, on account of the similarity of its coat to the branch on which it rests, it remains unnoticed by the casual observer. At the approach of evening, however, he ascends into the air, and there darting about in every direction he procures his food, which consists of various kinds of insects; now he is by no means silent, but makes the night resound with his shrill cries, varying the entertainment occasionally by diving from a great height with partially closed wings, and making a noise which, as Nuttall says, resembles the sound produced by blowing into the bung-hole of an empty hogshead. Early in June you may perhaps witness their courtship. The male is all attention, strutting around with spread tail and ruffled feathers, for all the world like a miniature turkey-cock; stopping now within a short distance of his charmer, he ducks his head and wags his body from side to side, uttering all the while a growling sound which seems to come from the very depths of his distended throat. During this time the female is apparently regardless of this mass of fuss and feathers, and sits perfectly still—a sweet picture of modesty; this is continued for some time, when off my lady goes sailing through the air, leaving her suitor to follow at his leisure. Audubon says, "The male may be said to court his mate *entirely on the wing*, strutting as it were through the air." In this statement, however, he is hardly correct, as for the last three years a pair of these birds have used a roof a few feet from my window as a trysting-place, and there evening after evening the little domestic drama just described was enacted, thus offering me a superior opportunity to witness their love-making.

The night-hawk builds no nest, but deposits her two speckled eggs on the ground, usually selecting some ledge for this purpose. Birds of this species are very numerous in New England, and in walking a few rods I have often seen numbers of them perched on the trees which border our streets. Still, for a long time I had been unable to find their breeding-grounds, for there seemed to be no suitable places near their favorite resorts; at last, however, I found that they made use of the house-tops for this purpose, and several pair with young or eggs were discovered so situated. I have never seen the fact mentioned, but it is undoubtedly true that these birds return to their old haunts year after year, and deposit their eggs on the same spot for successive seasons. Some years ago I found two young birds just out of the shell; and the next year, being in that vicinity, I had the curiosity to visit the place, and there on the very same spot were two eggs; again the following season it was occupied by the birds. They sometimes raise two broods in a season, as was proved to me by finding two young birds about to fly, and shortly after two more eggs were deposited on the same spot. This is, I believe, contrary to their usual practice, however. A very strange peculiarity which these birds exhibit is that of removing their eggs upon being disturbed during incubation. I visited a pair that had deposited their eggs on the house-top, and the next day was surprised to find them gone, for the situation rendered them unapproachable by other than myself; but a little search revealed the fact that the eggs had been moved to another part of the roof, about a rod from their former resting-place. This removal is perhaps made by taking the egg in their very large mouths, in the manner described by Audubon. In speaking of chuck-will's widow, an allied species found in the South, he says: "When chuck-will's-widow, either male or female (for each sits alternately), has discovered that the eggs have been touched, it ruffles its feathers and appears extremely dejected for a minute or two, after which it emits a low, murmuring cry, scarcely audible at a distance of more than eighteen or twenty yards. At this time the other parent reaches the spot, flying so low over the ground that I thought its little feet must have touched it as it skimmed along, and, after a few low notes and some gesticulations, all indicative of great distress, takes an egg in its large mouth, the other bird doing the same, when they fly off together, skimming closely over the ground, until they disappeared among the branches and trees."

On any of our streams or lakes, whether in the unbroken forest or where civilization reigns, we may find the kingfisher perched on some stake or rock, surveying the water beneath him with eager eye in search of his finny prey, or skimming over the surface and uttering his harsh cry, which is so similar to the sound of the watchman's rattle that we can easily imagine some guilty sojourner in our native wilds, who hears it for the first time, starting from his slumbers, thinking that the Philistines were upon him.

In Williamson's "History of Maine" is given a list of our native birds, or what purport to be so, and there a very strange mistake is made in his description of the kingfisher. He says, "It is heavy as a plover, has a long bill, its head is crested with *red*, its back is of a blue color." He also says that this bird is plentiful, but it is very evident from his description that he never examined one, since the bird's entire upper parts, including the head, are ashy blue. These birds excavate in sand-banks a hole about six feet deep and three and a half inches in diameter; this hole is enlarged at the end, where, as Audubon, Nuttall, Samuels, and other authors agree in saying, a nest is built, composed of grasses, leaves, feathers, and perhaps a few sticks, on which the eggs are deposited. This, however, is not the case in central Maine, for I have examined a great many of their burrows, with a view to ascertaining the facts regarding the construction of their nests, and in *not a single instance* has there been the slightest attempt at the formation of a nest, but the eggs were laid on the bare sand, over which in some cases fish-scales were scattered. I have spoken with many persons in different parts of this State in regard to these facts, and their observations have agreed with my own. Mr. H. D. Minot, in his "Land and Game Birds of New England," says: "From the abundant evidence recently offered on the subject of the nest, and from my own limited experience, it may be gathered that it" (i. e., the burrow) "varies in length; . . . that it may be either straight or have a bend, and that it is rarely lined at the end, except with *fish-bones*, as is sometimes the case."

When all Nature is covered with her snowy mantle, and our feathered friends have deserted us for more congenial climes, we may still see the red-bellied nuthatch hopping about on our trees, peering into crannies in search of food, and uttering their short and ceaseless note; but, as the weather grows milder, they gradually disappear, going away to the north, where they breed. The author of "Land and Game Birds of New England" notes that a nest was found in Roxbury, in 1866, but the instances recorded of its nest and eggs being found in New England are not common, and for this reason I trust the description of a nest and eggs which I was so fortunate as to find may be of interest. On the 23d day of May, 1877, while passing through the woods on a collecting tour, I chanced to place my hand on an old and very much decayed hemlock-stub, but no sooner had I touched it than a red-bellied nuthatch popped out of a hole about six feet from the ground, and, feeling sure of a prize, I proceeded to inspect her snug quarters. The nest was placed in a cavity in the stub, which extended downward about six inches below the entrance: at the bottom of this hole was the nest proper, which was composed entirely of soft bark;

it was about three and a half inches across and slightly hollowed, perhaps three quarters of an inch. This nest contained six eggs, speckled with reddish-brown.

Around the hole on the outside of the stub a circle of fresh pitch had been smeared by the birds, perhaps for the purpose of keeping out the ants with which decaying stumps are apt to swarm. I have never before heard or read of this habit; none of our ornithologists, so far as I can learn, make any mention of the fact; but since the above instance came to my notice I have learned of another case of the kind, where the stub was a white birch, showing that my example was not altogether exceptional, and the fact that it is unnoticed by our ornithologists may be owing only to a scarcity of observers.

The geographical range of different species of birds is not so definitely marked as might be supposed, for, although there are certain well-defined boundaries which separate the birds of different parts of the world, and of different parts of the same country, yet these limits are being constantly broken over by accidental visitors from other countries, by the birds increasing their range, or by stragglers from other ornithological districts of the same country. A South American humming-bird was obtained at Cambridge, Massachusetts, a few years ago. The Egyptian neophron has been shot in England, and the European corn-crake is occasionally found on the Atlantic coast of the United States.

The cliff or eave-swallow, perhaps, furnishes the best example of increased range to be found among our birds. When first discovered it was apparently confined to limited areas in the West and Southwest, but at present it spreads over nearly the whole country and is yearly increasing its limits.

In order to be more fully understood in speaking of ornithological districts, it may be well to cite as examples the two regions of New England sometimes called the Alleghanian and Canadian. These districts are divided by a line drawn from the coast of Maine, near Mount Desert, and running southwesterly on the ridge of high land which extends across the southern portion of the State into the highland region of New Hampshire, thence running northwesterly across Vermont. This division is so marked that some birds that are common in the southern district are almost unknown in the northern, where they may occasionally appear, however, as stragglers. Much more striking examples are sometimes seen, as in the case of a cardinal grosbeak that was shot at Orrington, in Maine, a few years since—this bird's habitat being the southern portions of the United States.

I recently had the pleasure of following up and reporting a most interesting case of the finding of birds beyond their supposed limits. In this instance the bird was the loggerhead shrike (*Collurís ludovicianus*), which is a resident of the Southern States, and not supposed to breed in New England. As the case is one of considerable interest, I shall state the facts in full. On May 5, 1877, a nest, four eggs, and parent bird, were obtained near Bangor, Maine, which the finder believed to be the great northern shrike (*C. corealis*), and it was described as such in "The Oölogist." Later in the same year another nest was found, and the parent bird shot. The following year four more nests were obtained, and some eight birds procured, some being immature specimens. During this latter season (1878), I obtained some of the specimens mentioned, and was surprised to find that they were not great northern but loggerhead shrikes. Soon after this, at the request of Dr. T. M. Brewer, of Boston, I made a thorough inquiry into the facts concerning the breeding of shrikes near Bangor, and then examined all the specimens of both birds and eggs that had been procured. The result showed that there was not a single authentic instance of the great northern shrike's breeding in this vicinity—every reported instance proving that the bird in question was the loggerhead species.

Until brought to my notice, these birds had never been known to breed in New England, and I had the gratification of being the first to so report them. Minot, in his "Land and Game Birds of New England," says that "they are but rarely found as far north as Massachusetts." Since their discovery here, however, Dr. Brewer has been making extended inquiries into the breeding of the shrikes in New England, and it now appears that in several other cases, where great northern shrikes were reported as breeding, the birds have proved to be loggerheads. This was true of the specimens found at Rutland, Vermont, as stated by Dr. Brewer in the "Ornithological Bulletin" for April, 1879. These birds now appear to be regular visitants in this vicinity, and are among our earliest arrivals. About the first of May of this year (1879), I found a nest containing one egg, and on the 28th day of the same month I found another nest with six young.

All of the nests found here, so far as can be learned, were situated in rather open fields, and none were in the deep woods. The birds were not easily alarmed, and apparently cared but little for the presence of man. Sometimes they would perch on an adjacent limb and watch me, as I examined their nests, without showing a sign of fear. It is certainly quite remarkable that a bird with such marked characteristics should dwell with us long, if indeed it has done so, and yet escape notice; and the number of instances of its breeding here which have been reported since its presence was first noted is also remarkable if it is a straggler.

The author of "Land and Game Birds of New England" claims the honor of being the first to discover the nest of the golden-crowned kinglet (*Regulus satrapa*), which discovery he made in 1875 in a forest in the White Mountains. This nest contained six young birds, but no eggs.

Wilson and other ornithologists, believing that the European "gold-crest" and our *R. satrapa* were the same, took a description of the nest and eggs of that bird and applied it to our "golden crown," but the birds are not identical.

If Mr. Minot is correct, as he undoubtedly is, it is probable that I have the pleasure of possessing the first and possibly the only nest and *eggs* of this bird ever found. In 1876, the year following Mr. Minot's discovery, I obtained a nest which contained ten eggs. It was found near Bangor, Maine, and was placed about six feet from the ground in a mass of the thick growth so common in many of our fir-trees. The nest was composed of a large ball of soft moss, forming a mass about four and a half inches in diameter. The opening was at the top, and was about one and three fourths inch across and two inches deep; this opening was lined with hair and feathers, principally the latter.

To the eye the eggs appear of a creamy-white color, covered with such very obscure spots that they merely give a dingy or dirty tint to the egg; but Dr. Brewer, who examined them by the aid of a powerful magnifier, states in the "Ornithological Bulletin" for April, 1879, in which he gives an account of these eggs, that "the ground-color is white, with shell-marks of purplish slate, and a few obscure superficial markings of a deep buff, giving to the ground the effect of cream-color." These eggs are extremely minute, the largest being only $\frac{52}{100}$ of an inch long and $\frac{41}{100}$ of an inch in breadth, while the smallest is $\frac{47}{100}$ of an inch long and $\frac{39}{100}$ of an inch in breadth, or about the length of the egg of the ruby-throated humming-bird. These ten tiny eggs in their mossy casket can hardly be excelled for simple beauty.

There are many persons who do not feel particularly interested in natural history in general, but who are nevertheless charmed by our beautiful birds and their sweet songs, and, being touched through the medium of their senses, they come by degrees to learn more and more of their habits, till the charm so grows upon them that without our feathered friends life would lose one of its greatest pleasures. Yet, perhaps, no living creatures are so much abused, being a convenient target for every boy who is large enough to carry a gun or throw a stone. In some localities there is a constant robbery of their nests, carried on to an alarming extent, which the law is practically powerless to prevent. Take a single example of failure to enforce the law in another direction: I am informed that over seven thousand ducks were netted contrary to law in Franklin, Maine, last year, by pot-hunters, and all over our State this business is carried on with impunity, and probably will continue to be till public sentiment is aroused to a proper realization of the fact that our waters are gradually being stripped of their water-fowl, and when it is, perhaps, too late, the wrong which has been permitted may be appreciated but too well.

THE NEW CHEMISTRY, A DEVELOPMENT OF THE OLD.

By M. M. PATTISON MUIR, F. R. S. E.

IN a former paper* I endeavored shortly to summarize the more important differences between that system of chemistry which was founded on a so-called equivalent notation and the modern, or atomic phase of the science. The general conclusion to which that summary led was, that the old chemistry was empiric, while the new is scientific ; but, as was there remarked, empiricism precedes science : science is the natural development of empirical statements, and is not to be regarded as entirely a new departure.

Believing, as I do, that the old and new chemistry are essentially opposed in their methods, I nevertheless am certain that the germs, at least, of many of our modern chemical theories are to be found in the statements, and even in the hypotheses, of the workers of half a century since : and in the present paper I propose to trace, in a little detail, what I believe to be a correct outline of the development of two of the more important theories of modern chemistry. †

The chemical views most in vogue before the strictly modern epoch were founded more on considerations of the composition of compounds than on the actions of these compounds. Dumas introduced wider views by recalling the attention of chemists to the fact that, in order to frame even a tolerably complete system of classification, an answer must be given to the question, "What does this substance do?" no less than to the other question, "Of what is this substance composed?"

But, if we go back to the time before Lavoisier and his associates, we find that the system then predominant in chemistry was founded almost entirely on the reactions, and but to a very small extent on the composition, of chemical substances. Chemists then busied themselves continually with studying processes of chemical change ; only they contented themselves with qualitative knowledge, and hence their hypotheses were for the most part extremely vague and their facts disconnected. John Joachim Beecher, born about 1630, seems to have been the first to weave together the scattered chemical facts and guesses into a consistent general theory, which was subsequently augmented and defined by Stahl (1660–1734).

Looking at the wonderful changes produced in substances by the action of chemical force, the question arose, What happens when a body undergoes chemical change ?—and, as burning or combustion was

* "Popular Science Review," January, 1878.

† In the paper referred to, I briefly sketched the history of the development of the older doctrine of "Equivalents" into the modern hypothesis of "Valency."

perhaps the commonest of all chemical changes, the question became narrowed, and chemists eagerly sought for an answer to the query, "What happens when a chemical substance burns?"

In those days natural phenomena were referred to the presence of "principles" or "essences" in the matter exhibiting the phenomena. A new principle was added to the list; and the question was supposed to be solved by saying that combustible substances are characterized by richness in *phlogiston* (Gr. *phlogizō* = burn, or inflame), and that when they burn they lose this principle, so that the burned substance, or calx, consists of the original substance *minus* phlogiston.

The phlogisteans seem to have regarded their hypothetical principle as a modified form of fire, as fire confined in a material substance; but, as they gave no definition of fire, beyond saying it was one of the four elements, it was scarcely to be expected that they should define phlogiston. By restoring phlogiston to the burned substance, said the theory, the original matter is regenerated. Some substances, e. g., charcoal, are especially rich in phlogiston, and metallic calces may be converted into metals, i. e., may be unburned, by heating them with charcoal. Thus the phlogisteans regarded the phenomena which they studied in a purely qualitative manner: they asked only, What does this or that substance do under given conditions? not being aware that a full answer to this question can only be given when the other question—*How much* of some given effect is produced by a given quantity of this body under stated conditions?—had been answered.

The introduction and use of the balance carried the day in favor of those who opposed phlogistic views. If a substance loses something when it burns, it *must* weigh less than before burning—as a fact it weighs more—therefore it has not lost but gained something.

"Nay," replied the phlogistean, "it has lost something, but the weight of this something can only be expressed by a negative quantity."

"But a something with such properties is an absurdity," replied the opponent; "therefore it has no existence, and therefore your theory is utterly false."

The anti-phlogistean triumphed, and the principle of levity was banished from chemical science. But the principle returned in a modified form. Lavoisier, who opposed the Beecherian theory of phlogiston with signal success, himself propounded a theory of the constitution of solids, liquids, and gases, in which the "subtle principle" "*caloric*" played an important part. Lavoisier regarded oxygen as what he termed "concrete oxygen" *plus* a something—caloric; indeed, he appears to have looked on all substances in the concrete state as solids, and to have supposed that the addition of a certain quantity of caloric to these caused them to become liquids, while the addition of a further quantity of caloric produced gases.

Thus chemists seemed obliged to imagine a something in addition to the gross or ponderable matter of which bodies are composed, in order to account for the properties of these bodies. As Science has advanced she has been able to define what this something is; at least, she has defined it more clearly than the older workers could do.

I have said, as Science has advanced she has defined the unknown something; but it should be remembered that that wonderful book, which contains—according to the greatest authorities—the germs of all our modern advances, was written sixty years before Lavoisier's time. Sixty years before the apparent overthrow of the theory of phlogiston, Newton had laid the foundations of the science which was to reveal the true lineaments of that Unknown whom the phlogisteans ignorantly worshiped.

We have learned to extend the meaning of the word *thing*—we speak of "the power of doing work" as a measurable and definite thing—although not as matter: and we know that when a body burns it loses a certain amount of this power of doing work, or, as it is more shortly put, of energy. As usual, it is a question of words. The older workers could not define phlogiston; we are able to define energy, and therefore we can see clearly where they saw but darkly. Chemistry now acknowledges that the properties of a compound are not only determined by the composition of the matter of that compound, but by the amount of energy associated with that collocation of matter. She has been able to point out many instances of compounds composed of the same matter, but possessed of different amounts of energy, and, at the same time, of very different properties. And, moreover, chemistry aided by physics has concluded that the properties of a body "are dependent on the variations of the energy of the body, and not on its total value," and therefore that "it is unnecessary, even if it were possible, to form any estimate of the energy of the body in its standard state." (I quote from that remarkable little book of the late Professor Clerk Maxwell, "Matter and Motion.")

Whenever Science made the advance from the vague conception of "principles" and "imponderable matter" to the definite conception of "mass," "motion," and "energy," she was able to recognize the truth which lurked under the cumbersome and inexact nomenclature of the phlogistean chemists.

I have said that, as usual, the dispute between the phlogisteans and their opponents was proved to be a question of meaning of words: as usual, also, subsequent research showed that, while both were wrong, both also were right.

Composition is important, but composition is not all. The burned body has properties differing from those of the unburned body, because it has lost a certain amount of "the power of doing work"; but it has a less power of doing work because it is possessed of a structure different from that which it possessed before. Composition and properties, energy and structure, are closely connected: to determine the exact relations existing between these, under stated conditions, is still the fundamental problem of chemical science.

We can define energy: the phlogisteans could not define phlogiston. But in the ethereal philosophy of the future will it not be said of the present workers in science that they could not define ether, but even spoke of it at times as "not gross nor ponderable matter"? The theory of phlogiston was continued and developed in the theory of caloric: the theory of caloric is vastly extended, simplified, and rendered definite in the theory of energy, and the theory of energy seems destined to be largely extended by the ethereal theory now in its infancy.

Mankind has until lately been content with space of three dimensions, but the bolder and more dashing spirits among the mathematicians have dared to look forward to a better world than this where they may revel in space of four dimensions. What a strange world must that be! what a fearful place for a mathematical examination, when we remember that the inhabitants thereof—if there be inhabitants—may turn spherical hollow balls inside out without tearing or breaking them!

While we look forward to the future of science with hope, I think we ought not to look back on the former workers without respect.

But I must pass on to consider the second of the great theories which have paved the way for the doctrines of modern chemistry. The germ of the modern ideas of substitution, valency, atom-linking, etc., is, I believe, to be found in the pure dualism of Berzelius; and, moreover, the influence of the dualistic ideas of that great chemist seems to me easily traceable in the essentially unitary system of modern chemistry. The chemistry of Lavoisier centered around the wonderful substance whose properties he so carefully studied. The teaching of the great founder of modern chemistry was saturated with ideas suggested by the study of oxygen. The compounds of oxygen were divided by Lavoisier into two groups, bases and acids: when these reacted chemically, a salt—that is, a body made up of base and acid—was produced. Berzelius developed these ideas until he had constructed a complete and beautiful theory, viewed in the light of which all compounds were of analogous structure. Every chemical substance was made up, according to the Swedish chemist, of two parts; these parts might themselves be composed of simpler parts, or they might be truly elementary. The two parts of a compound were respectively endowed with positive and negative electricity. When two bodies combined, the positive electricity in one neutralized the negative electricity in the other; hence the phenomena of light and heat noticed in chemical combination. An element might contain an absolutely greater quantity of positive electricity than another and nevertheless belong to the electro-negative series of elements: thus sulphur and oxygen readily combine to form a substance which, when dissolved in water, yields an acid. But oxygen and sulphur are both electro-negative elements. Berzelius supposed that sulphur contained a large quantity of both electricities, the negative predominating. When this element combined with oxygen, the positive electricity of the sulphur was supposed to be neutralized by the negative electricity of the oxygen, so that the negative electricity of the sulphur was concentrated or rendered more apparent. The affinity between oxygen and silver is less than that between sulphur and oxygen, because, said Berzelius, silver contains mainly positive electricity, but a smaller quantity than is found in sulphur. The product of the union of oxygen and sulphur, i. e., of oxygen with an electro-negative body, belongs to the class of acid oxides ; the product of the union of oxygen and silver, i. e., of oxygen with an electro-positive element, belongs to the class of basic oxides.

If this view of the composition of oxides were granted—and a most ingenious and plausible theory it was—why should we not proceed a step further and say that an acid acts so readily upon a base, because, in the first, negative electricity predominates, while the prevailing electricity in the latter compound is positive?

And, in further support of this view, could it not be experimentally demonstrated that when a salt, such as sulphate of sodium, is decomposed by the electric current, the soda goes to the negative pole, while the sulphuric acid appears at the positive pole ? The experiment of decomposing a solution of sulphate of sodium was frequently performed, and the fact that, if the solution were colored with litmus, that portion around the negative pole retained its blue color, while that around the positive pole became red, was regarded as conclusive evidence of the dualistic structure of the salt operated upon.

But, about the year 1834, Dumas told the chemical world that chlorine was capable of "laying hold of the hydrogen of certain bodies and replacing it atom for atom." If this be so, said Berzelius, the compound formed must differ essentially from that from which it is derived. Chlorine is an electro-negative element, and, if it enter into a compound in place of the electro-positive hydrogen, the original compound and the new compound can present no points of analogy. The theory seemed correct, but unfortunately the chlorinated body did present very marked analogies with that from which it had been produced. Berzelius attempted many explanations, invented many new compound groups of atoms, which should be supposed to enter into the composition of the new bodies discovered by Dumas ; but his electro-chemical theory was doomed. It was gradually abandoned by most chemists, and the substitutionists carried the day.

Berzelius had largely availed himself of certain facts, which showed that, in series of reactions, it was sometimes possible for a group of dissimilar atoms to remain intact, to move about, so to speak, from one compound to another without falling to pieces. Reasoning on these facts, he constructed formulæ for all compounds, which formulæ were made up of two parts, or radicles. The idea of compound radicles was thus closely associated with the dualistic theories of the Berzelian school. The new school, led by Dumas, finding dualism insufficient to explain many weighty facts, naturally waged war against the fundamental conception of compound radicles, but they were soon obliged to accept the essential truth of the theory which they at first opposed. Liebig and Wöhler's research on oil of bitter almonds led to the discovery of a number of compounds, exhibiting many general analogies, which could best be explained by supposing the existence in each of a compound radicle, or group of atoms. When it became necessary once more to adopt the idea of compound radicles, the theory of substitution was found to be strengthened, not weakened, thereby. Many reactions were made clear by supposing that an element might be substituted by a group of elementary atoms, by a compound radicle. But in adopting the idea of compound radicles the substitutionist yet maintained that the chemical compound was a distinct whole, made up of parts he admitted, but, nevertheless, having these parts so modified and merged in one another that the resultant acted as an homogeneous compound. Thus, when the new school likened the ethers to the metallic oxides, they did not mean to assert that the molecule of ether was composed of two parts, ethyl and oxygen, held together by electric bonds, and ready to part company without difficulty; nor, in asserting that ether was one substance, and not a dualistic system, did they deny the existence of a structure within the molecule of ether. They admitted the existence of a closer relationship between the atoms of carbon and hydrogen constituting the group ethyl than between these atoms and those of oxygen, and they generalized the reactions and analogies of ether, by saying that it might be regarded as sodium oxide in which both sodium-atoms had been substituted by two compound atoms of ethyl. Berzelius had himself likened the ethers to oxide of potassium, and by doing this the great apostle of dualism had paved the way for the advance of the unitary theory.

That portion of the dualistic doctrine which was embodied in the theory of compound radicles was adopted by the unitary schools, but adopted in a modified form; the effects of this modification were not long in making themselves felt.

Berzelius, in his later works, had been ready to give a dualistic formula to any compound without stopping to inquire into the facts known about that compound; he had tended to forsake the only true scientific method, and to substitute the vagaries of his fancy for the facts of nature. The new school averred that "compound radicle" was an expression generalizing a class of facts; that the reactions of bodies were most simply explained by supposing that when acted on by chemical force the little parts of these bodies behaved as having a definite structure; and that therefore the formula of a given body might be written as containing different compound radicles under different conditions.

The fault of the old chemistry was that more attention was paid to symmetrical formulæ than to reactions; the merit of the new consisted in bringing the student once more back to nature.

And the appeal to nature was answered, and answered abundantly. The new conception of compound radicles was rich in results; from it there was developed—first, the theory of types, and, subsequently, the wider theory of valency, which has led to that of atom-linking, and these in their turn have reacted on the older and more fundamental notions of the science, and have given a new meaning to such terms as "chemical" and "mechanical actions," "compounds" and "mixtures," etc., while, at the same time, they point the way to the chemistry of the future when we shall have gained a definite conception of the inner mechanism of the molecule, and of the laws which regulate the combinations of molecules in groups, and the decompositions of molecules with subsequent formations of new atomic systems.

Let us shortly examine these ideas. If sodium be thrown on to water, caustic soda is produced, a substance made up of hydrogen, oxygen, and the *simple radicle* sodium; by another reaction a substance can be obtained consisting of hydrogen, oxygen, and the *compound radicle* nitryl (NO_2). These two bodies have analogous formulæ, Na OH and (NO_2) OH, they may both be regarded as derived from water, H HO, by the replacement of one half of the hydrogen by a radicle; in one case by Na, in the other by NO_2. Again, the whole of the hydrogen in water may be replaced by sodium, with production of the compound sodium oxide, Na_2O.; but in many of its reactions this compound is the analogue of common ether, which is also a compound of oxygen with a (compound) radicle *ethyl*, and has the formula $(C_2H_5)_2O$. Now, these substances, Na OH, (NO_2) OH, Na_2O, and $(C_2H_5)_2O$, both on account of the methods by which they are produced, and because of their general reactions, may be classed together as derivatives of water, or may be said to belong to the *water-type*. Similarly, other types have been instituted, and large groups of compounds have been brought into the same class as being all referable to one parent type. This step in advance is evidently an outcome of the theory of compound radicles; without that conception a system of classification by types would have been impossible.

But it was found that while such compound radicles as C_2H_5 or NO_2 were capable of replacing but one part by weight of hydrogen in water, other compound radicles, such as CO or C_2H_4, were capable of taking the place of two parts by weight of hydrogen. Comparing together these two sets of radicles, it might be said that $CO = 2\ NO_2$ or $C_2H_4 = 2\ C_2H_5$, so far as the power of combining with hydrogen was concerned. This conception of binding power being extended to the elements, and being deepened and widened by laborious experimental researches, led to the general theory of valency, which included in itself the essential features of the older doctrine of equivalents.

Having thus gained the conception of a definite binding power as applicable to elementary atoms or groups of atoms, it followed, as an almost necessary deduction, that the smallest parts of chemical compounds which existed as distinct chemical entities, i. e., the molecules, must have a definite structure: that the parts (atoms) of the little systems must be arranged in accordance with the valencies, or binding powers, of these parts.

Hence, given the number of atoms in a molecule, and the valency of each atom, it became possible to calculate the number of different arrangements of these atoms which could be produced; and careful experiment has often succeeded in preparing all the different, theoretically possible, compounds. The difference of properties of such compounds, i. e., of compounds the molecules of which are constituted of the same number of the same atoms, but differently arranged, is attempted to be indicated in the "structural" or "rational" formulæ of modern chemistry.

Berzelius spoke of compounds composed of parts held together by mysterious bonds: the idea survives in these structural formulæ of to-day, only we are now able to define what we mean by the smallest part of a compound having a chemical existence, and we have gained certain generalizations which enable us to trace with some degree of accuracy the relationships which exist between the inner parts of these smallest chemical wholes. We appear to be now fairly embarked in the prosecution of molecular dissection, and our chief guide is the theory of valency, itself a development of the dualistic chemistry.

Each elementary atom, I have said, seems to have the power of directly binding to itself a maximum number of other atoms; but it would further appear as if the groups of atoms thus produced had also a certain binding power, but this more indefinite than the atomic binding power, and very variable under different physical conditions. This atomic binding power appears to have a fixed maximum value, but not always to reach the maximum. What is the exact way in which the binding power or valency of the elementary atoms is influenced by definite changes in physical conditions? This is one of the most important unsolved problems of general chemistry.

Then, again, granting the existence of an inner structure to the molecule, granting that groups of atoms do exist in the molecular building, does the fact, that in a certain reaction certain atoms are withdrawn as a group, prove that these existed in the form of the same group in the original molecule? In other words, do our structural formulæ express the relative collocation of atoms within the molecule while the molecule is unacted on by extraneous force, or do they merely roughly represent the condition of things when the molecule is in a state of strain, because of the stress between its parts and those of another molecule, or molecules, brought within its sphere of action? Here is another question which can only be answered after much experimental evidence has been accumulated. Now, these questions, I make bold to say, are the direct outcome of the dualism of Berzelius, modified by the unitary chemistry of Dumas and his followers.

If we glance back on the development of the two theories, the course of which I have endeavored to outline, we find that both began with a purely qualitative study of reactions, but that it was only when to this had been added the careful use of weights and measures that any solid advance became possible. Further, we find that the older theory was founded chiefly on a study of reactions, while that which was broached after the time of Lavoisier was founded most largely on a study of composition. With the phlogisteans *function* was of paramount importance; with the dualists *composition* was all. The modern theories, which have been developed from these, have attempted, with varying success, to combine both considerations. And if we examine the latest advances of theoretical chemistry we still find it at work on these two lines of advance. The composition of chemical compounds is studied by the majority of chemists; but the general laws of action of chemical force itself have of late received most important elucidation.

Again, if we look to the "lines of advance along which dynamical science is working its way to undermine, at least, the outworks of chemistry," we can distinguish two, essentially the same, lines as were used by the two classes, whose theories I have dealt with in this paper. "One is conducted by the help of the hypothesis that bodies consist of molecules in motion, and it seeks to determine the structure of the molecules and the nature of their motion from the phenomena of portions of matter of sensible size. The other line of advance, that of thermo-dynamics, makes no hypothesis about the ultimate structure of bodies, but deduces relations among observed phenomena by means of two general principles, the conservation of energy and its tendency toward diffusion." (Clerk Maxwell, "South Kensington Science Conferences," 1876, p. 145.)

I have thus sought to substantiate the claim of the new chemistry to be a development of the old. I believe that, if this claim is granted, the conclusion to be drawn must be, not that the old is better, but that to return to that which is admittedly an early stage of development would be to misread all the teachings even of the old chemistry itself.

In examining the progress of Science we see that she is not afraid to retrace her steps, and that she is able to retain and develop all that is probably true, while rejecting all that is proved to be false; and, when we learn that she does this, can we hesitate to find in her history the "promise and potency" of a mighty future?—*Popular Science Review.*

SKETCH OF FRIEDRICH MOHR.

By FREDERICK HOFFMANN.

ON September 28, 1879, the earthly career of a man closed at Bonn, Germany, whose numerous original researches and contributions to pharmacy, chemistry, chemical analysis, geology, and other branches of the physical and applied sciences, have placed him in the foremost ranks of scientific investigators. Karl Friedrich Mohr was born November 4, 1806, at Coblentz, on the Rhine, where his father was an apothecary. After having completed the full course of the gymnasium of his native city, he entered, in 1823, his father's establishment as an apprentice. In 1828 he went to the University of Heidelberg, where he applied himself to the study of philosophy, the natural sciences, and pharmacy, and where, by the influence and guidance of Leopold Gmelin, his interest was particularly drawn to chemistry; he subsequently studied at the Universities of Berlin and Bonn, and in 1831 graduated as doctor of philosophy. After having passed the state-examination as apothecary, in 1832, he returned to Coblentz, and became the assistant, and, in 1840, the successor of his father, in business.

Mohr's first literary production was an essay on the nature of caloric and the conservation of force, published in "Baumgaertner's Journal," in 1837, in which the principle of the unity of natural forces and the law of equilibrium, now generally adopted, were for the first time exactly and fully defined, and, five years afterward, were established on a firm mathematical basis by Robert Mayer, of Heilbronn, and, still later and more fully, by the experimental researches of Joule, in England.*

His application to practical pharmacy led Mohr to again enter the field of pharmaceutical and chemical research; he undertook the completion of the comprehensive work "Pharmacopœia Universalis," projected by Professor P. L. Geiger, who died in 1836, shortly after the publication of the first part of that work, embracing the crude drugs and simple chemicals. The second part, by Mohr, was published in 1845, and contained the formulary of pharmaceutical and chemical preparations of the various European pharmacopœias in use during the preceding seventy-five to eighty years, and including, of American works, the United States Pharmacopœias of 1820 and 1830, Coxe's "American Dispensatory," and Ellis's "Formulary." His application to the details of practical pharmacy and of chemical operations, his wonderful skill and inventive mind, resulted in the improvement and completion of old, and in the construction of a large number of novel

* "Popular Science Monthly," vol. xv., pp. 397–407; ibid., vol. v., pp. 103–107; "Archiv der Pharmacie," vol. 216 (1880).

apparatus, appliances, and processes in pharmacy and chemical analysis, which he embodied in his "Lehrbuch der pharmaceutischen Technik" ("Manual of Pharmaceutical Practice"), published in 1846. This remarkable work has since been reprinted in five editions, and has been twice translated into French, and into English by Professor Redwood, of London, and edited for American use, in 1848, by the late Professor William Procter, Jr., of Philadelphia.

In 1847 Mohr completed a commentary on the Prussian Pharmacopœia in two volumes, a work replete with original research and thought, and characterized by frank critical analysis of both the excellences and the defects of the Prussian standard. This work has also been republished in five editions. A smaller volume on the art of dispensing (Receptir Kunst), mainly intended for the instruction and use of physicians, published in 1854, completes the list of Mohr's separate pharmaceutical works, while his numerous contributions to the pharmaceutical journals of Germany, continued almost during his lifetime, were of great importance, covering the domain of practical pharmacy, and embracing many processes as well as manipulations and apparatus, invented or perfected by him and now widely adopted and in general use everywhere.

The principles and great practical value of the volumetric method of estimation in chemical analysis, recently introduced by Gay-Lussac, Marguerite, and others, attracted at once Mohr's quick and inquisitive mind; recognizing both the simplicity and accuracy of this method, he promptly applied his study and talents to its improvement, and soon brought volumetric analysis to such a perfection and comparatively ready execution that his "Manual of Volumetric Analysis" ("Lehrbuch der chemisch-analytischen Titrirmethode"), published in 1855, met with general and unqualified acceptance; since then four revised and enlarged editions have been published, and it has been translated into most civilized languages, and up to the present time is regarded as the standard work in this branch of chemical analysis, which has been of great value and use in the development and advance of chemical industry.

During these active years of Mohr's life it was, however, not only the practical and analytical application of pharmacy and chemistry that received his attention and the fruits of his labors and accomplishments, but likewise the theory of science and popular instruction; already in 1864 Mohr had established himself as "Privat-Docent" in pharmacy, chemistry, and geology at the University of Bonn, where he was appointed as Professor of Pharmacy and Chemistry in 1867, and where he published in 1868, aside from many scientific as well as popular contributions to journals, his most important work on theoretical chemistry, "The Mechanical Theory of Chemical Affinity," being a continuation and perfection of his first similar essay published in 1837.

At the meeting of the German scientists and naturalists in Bonn, in 1857, Mohr's interest was so much drawn toward the problems of geology that he henceforth devoted much study and research to geological investigations. Besides a series of excellent popular essays in "Westermann's Monatsheften," in 1866 appeared from his fruitful and highly appreciated pen "A History of the Earth," in which he advanced and sustained novel views on the origin of anthracite coal, the deposits of lime in the seas through the agency of plants, the occurrence of magnetic iron in basalt, and of metallic iron in meteorites, etc.

Mohr's works and writings, extending over a wide sphere of the physical and applied sciences, are characterized by strict scrutiny, clearness, and attractiveness; his attainments, learning, and eloquence were widely appreciated; during many years he delivered popular lectures on various branches, or special topics, or problems of chemistry or geology, at Coblentz, Bonn, Cologne, and other cities, and these lectures drew large audiences of the most cultured classes of society; the present accomplished Empress of Germany was, during her many years' residence in Coblentz, among his devoted hearers. His popular essays in "Westermann's Monatsheften" in "Gaea," in the "Cologne Gazette" and other German journals, were ever-welcome literary contributions of the highest order, and also entered largely into the literature of other nations. Distinctions and honors, never courted by his independent and stern character, were not wanting for him, both at home and abroad. Among American societies, the American Pharmaceutical Association and the Philadelphia College of Pharmacy had elected him an honorary member in 1868.

One year before his death, Mohr delivered, on the occasion of the annual meeting of the "German Apotheker Verein" in Coblentz, in September, 1878, his last address to the representatives of his original vocation—an oration which obtained a wide and just fame for its masterly exposition of the past, the present, and the future mutual relations of chemistry, pharmacy, and medicine, and of the accomplishments of pharmacy for the progress and growth of the other two.

Risen like his famous contemporaries Woehler, Heinrich Rose, Wiggers, Liebig, and others, from the ranks of pharmacy, and carried far off from her special sphere by his application and labors during an active career, Mohr again and again betook himself to his alma mater, and, perhaps more than any one of his collaborators contributed to maintain the high place and reputation of German pharmacy in the domain of physical research; and, among the many eminent scholars and investigators of his time whose names adorn the records of advance in sciences and arts, Friedrich Mohr's name will be an imperishable one in the history of pharmacy and of her offspring chemistry.

CORRESPONDENCE.

EVOLUTION IN AMHERST COLLEGE.

Messrs. Editors.

I HAVE the best authority for saying that President Seelye, of Amherst College, is not satisfied with the interpretations which have been put upon his letter to the "Observer," to the effect that "groundless guesses" are not yet taught at this college "as ascertained truths of science," and that the doctrine of the evolution of man, from the monkey or from any of the irrational animals, being in flat contradiction to all the facts of history, is only fit to be left with the sciolists. He is not willing that a wrong impression should be given to the public with respect to his attitude toward science in general and the scientific doctrines of evolution in particular; and he claims that it was very far from his intention, in his note to the "Observer," to place his college or himself in antagonism to either. It is only just to him, therefore, that he should be set right. I am authorized to say that he has long "firmly believed the current doctrine of evolution to contain a great truth, as well as a subtile error." Moreover, he maintains that "all great truths, whether styled evolution or otherwise, so far as they are truly scientific, are taught and encouraged at Amherst; that all investigations of science and all earnest efforts to widen the field of our knowledge find a cordial welcome there. In a word, that evolution, cosmological and biological, so far as it is scientific, is taught as a part of science; but that such atheistic, illegitimate, unscientific conclusions or assumptions as may apparently flow from certain unwarranted expositions of the law of evolution, together with all other illogical, irrational, and unscientific conclusions and dogmatic deliverances constitute the 'groundless guesses' and the 'subtile error'" to which he referred—"and that these find no favor at Amherst." President Seelye gives his unqualified assent to and adopts this statement of his own, and the position of the college, and thinks its publication will do good.

Besides, it appears that Le Conte's "Geology" was specially recommended by the President to the Professor of Geology as a text-book for his class before its introduction, and after a careful examination of the work. Moreover, that the new department in biology was introduced to the college through President Seelye's own proposal and urgency with the trustees, and this because he desired the college to have the best and largest teaching in so important a field; also that he turned the attention of the present instructor in biology in that particular line, and sent word to him while in Germany that he should especially make the acquaintance of Haeckel and his work. The President considers that he would be unworthy of his place if he were indifferent to or intolerant of the investigations of science, and expresses himself as the reverse of hostile to free thinking.

No lover of science can find any fault with the position of President Seelye in its new aspect, and it is certainly a matter for regret that he has been placed at all in a false or equivocal attitude. Of course, no one who knows him can for an instant entertain the thought that he intended to mislead or supposed he would mislead by his former statement.

Upon such a platform, if faithfully adhered to and its declarations rigorously carried out, and under such leadership, Amherst will certainly be entitled to a high place among those institutions of broad and thorough culture and catholicity of sentiment of which Harvard and the Johns Hopkins University are prominent examples—institutions which inspire confidence in American scholarship at home and give it character abroad. And the evolutionists at Amherst, who are working in their special departments, are to be most heartily congratulated that, unlike their less fortunate brethren at Yale, *they* at least have no one more ready to support them and lead them forward than the President of their own college, who says it is his "full belief that there was never more or better scientific instruction given in Amherst than now."

DANIEL G. THOMPSON.

NEW YORK CITY, *May* 20, 1880.

CRAYFISH FOR STUDY.

Messrs. Editors.

A CLASS of about ten of our teachers has been meeting once a week this term, and, with Professor Huxley's book in one hand and a crayfish in the other, we have endeavored to verify the statements of the book.

After reading your notes on the distribution of the animal in North America, the thought occurred to me that it might be a favor to some students to know where a supply could be had. If you think it will help along the study of natural history, you may say that I can furnish any reasonable number at a cost of, say, two cents each, which I would have to pay boys for collecting. Yours truly,

E. A. Gastman,
Superintendent of Schools.

Decatur, Illinois, *May* 18, 1880.

ANIMAL AFFECTION.

Messrs. Editors.

A story recently related to me regarding a remarkable display of affection in a pet monkey is so similar to one which I have just read in "The Popular Science Monthly" for March, that I am induced to send it to you as corroborative of the truth or probability of the latter.

An officer of the United States Revenue Marine Service, and now upon this station, informs me that several years ago he owned a monkey which was very intelligent, and became exceedingly fond of him. Returning home one day after a brief absence, the officer saw that the monkey was unwell, but could not account for its illness. It seemed to be in great suffering, but at the same time showed its joy at seeing his master. The latter raised him in his arms, and the monkey, taking him by each of his whiskers, looked into the face of his human friend and kissed him two or three times. After he had done this, the monkey fell back and died almost immediately.

It is reasonable to suppose that the animal had some knowledge of his approaching end, and intended his embrace as a final farewell to his master. The subject of the intellectual capacities of animals is too large a one for the limits of this letter; I will, therefore, do no more than call your attention to this instance of almost human feeling.

E. H. N.

Port Townsend, Washington Territory,
May 8, 1880.

EDITOR'S TABLE.

GOETHE AND THE ARTISTIC STUDY OF NATURE.

GOETHE, the German poet, was the author of a work, in two volumes with an atlas, on the subject of colors, in which he put forth an elaborate theory of his own upon that subject. It appears that fragments only of this treatise have been translated into English, and, as its views have never attracted much attention or become generally known, Professor Tyndall has done well in recently devoting a lecture to an account of them. We print this admirable address, which our readers will be sure to find entertaining and instructive. For, though the doctrines put forth by Goethe on chromatics are not in themselves important and have no rank as contributions to the science of color, yet they have an interest as the products of a genius now everywhere confessed, though as yet but imperfectly interpreted by the critics. That he was a man of a many-sided nature, of perfected culture, and in various lines of a lucid insight, is not to be denied; and these traits give great importance to the problem of the workings of his mind in whatever direction it was systematically exercised. The poet Bayard Taylor, the successful translator of "Faust," declared that he considered Goethe "to have had the most grandly-proportioned and full-orbed intellect that has yet appeared among men"; but Professor Tyndall is inclined to rank him, on the contrary, among those who may be described as mental "hemispheres; or, at least, spheres with a segment sliced away—full-orbed on one side, but flat upon the other." In what this incompleteness consisted is clearly shown in Professor Tyndall's address. Goethe's mental preeminence was on the æsthetic, imaginative, and literary side, and this so predominated as to disqualify him from entering into the true scientific method of the study of Nature. He held to the competency of poetic and artistic insight alone to discern the truth in natural things; he tried it, and achieved a partial success, which naturally confirmed the idea. He then undertook to carry out his method systematically in a chosen field, and failed so conspicuously as not only to settle the question against him, but to make his failure a landmark of modern intellectual history. The chief interest of the subject is, therefore, by no means the question of the status of Goethe; it is a question of the claims of antagonist methods in the views to be taken of the surrounding world.

The view ineffectually maintained by Goethe by no means fell with his failure; it had been too long and too firmly established. The poetic and artistic method of regarding Nature was the earliest; and it was inevitable that the mental procedures it involved should become the universal habit and the basis of culture. It was the all-accepted and all-sufficient mode of viewing the natural order. The poet and the painter pictured the world as presented to the senses and the feelings. Philosophy worked out, and theology enforced, the first rude interpretations of natural objects and events, as they were open to the observation of the senses. Literature, of course, embodied those current modes of thought which were occupied merely with the external aspects of things, and such interpretations as were possible with only this surface-knowledge.

This method was satisfactory for many ages; but there at length began to grow up a curiosity or desire to pry into things and see what would come of it. Men began to penetrate beneath the superficial show to the subtiler structures and underworking forces by which all appearance is determined. Thus science arose. It began in dissatisfaction with the shallowness of the knowledge of Nature and the insufficiency of its current explanations; and it began at the outset to devise new means of arriving at truth. Instruments of scrutiny, instruments of analysis, experiment, and dissection, were devised, and, by their diligent application, curious and startling revelations were made of the inner workings, the finer constitution, and the deeper harmonies of the surrounding universe.

This new procedure of science the poets and artists have ever been inclined to resent as a violence and desecration. Accepting Nature as disclosed to the senses, and interpreted by immediate intuitions, they oppose science as a heartless agency, inappreciative of beauty, and destructive of poetry and art. Goethe strongly shared this jealousy of science as an intrusive rival of the great arts that have enriched the life of man. He was not only a representative poet, powerfully dominated by æsthetic feeling and artistic sentiment, but he was also a philosophic thinker, and not without some scientific aptitude, and with these qualifications he was ambitious of becoming the champion of artistic and poetic ideals against the cold and ruthless processes of experimental science. He chose a branch of optics as the field of conflict, and Newton as his antagonist, with what result Professor Tyndall's paper sufficiently indicates. Professor Helmholtz, some years ago, gave a lecture "On Goethe's Scientific Researches," in which he treats his character and labors from the point of view here taken. We subjoin some passages from this instructive discourse:

Goethe, though he exercised his powers in many spheres of intellectual activity, is nevertheless, *par excellence*, a poet. Now, in poetry, as in every other art, the essential thing is to make the material of the art, be it words, or music, or color, the direct vehicle of an idea. In a perfect work of art, the idea must be present and dominate the whole, almost unknown to the poet himself, not as the result of a long intellectual process, but as inspired by a direct intuition of the inner eye, or by an outburst of excited feeling.

An idea thus embodied in a work of art, and dressed in the garb of reality, does indeed make a vivid impression by appealing directly to the senses, but loses, of course, that universality and that intelligibility which it would have had if presented in the form of an abstract notion. The poet, feeling how the charm of his works is involved in an intellectual process of this type, seeks to apply it to other materials. Instead of trying to arrange the phenomena of Nature under definite conceptions, independent of intuition, he sits down to contemplate them as he would a work of art, complete in itself, and certain to yield up its central idea, sooner or later, to a sufficiently susceptible student. Accordingly, when he sees the skull on the Lido, which suggests to him the vertebral theory of the cranium, he remarks that it serves to revive his old belief, already confirmed by experience, that Nature has no secrets from the attentive observer. So, again, in his first conversation with Schiller on the "Metamorphosis of Plants." To Schiller, as a follower of Kant, the idea is the goal, ever to be sought, but ever unattainable, and therefore never to be exhibited as realized in a phenomenon. Goethe, on the other hand, as a genuine poet, conceives that he finds in the phenomenon the *direct expression* of the idea. He himself tells us that nothing brought out more sharply the separation between himself and Schiller. This, too, is the secret of his affinity with the natural philosophy of Schelling and Hegel, which likewise proceeds from the assumption that Nature shows us by direct intuition the several steps by which a conception is developed. Hence, too, the ardor with which Hegel and his school defended Goethe's scientific views. Moreover, this view of Nature accounts for the war which Goethe continued to wage against complicated experimental researches. Just as a genuine work of art can not bear retouching by a strange hand, so he would have us believe Nature resists the interference of the experimenter who tortures her and disturbs her; and, in revenge, misleads the impertinent kill-joy by a distorted image of herself.

Accordingly, in his attack upon Newton, he often sneers at spectra, tortured through a number of narrow slits and glasses, and commends the experiments that can be made in the open air under a bright sun, not merely as particularly easy and particularly enchanting, but also as particularly convincing!

We have seen that Goethe rebels against the physical theory just at the point where it gives complete and consistent explanations from principles once accepted. Evidently it is not the insufficiency of the theory to explain individual cases that is a stumbling-block to him. He takes offense at the assumption made for the sake of explaining the phenomena, which seem to him so absurd, that he looks upon the interpretation as no interpretation at all. Above all, the idea that white light could be composed of colored light seems to have been quite inconceivable to him; at the very beginning of the controversy, he rails at the disgusting Newtonian white of the natural philosophers, an expression which seems to show that this was the assumption that most annoyed him.

To give some idea of the passionate way in which Goethe, usually so temperate and even courtier-like, attacks Newton, I quote from a few pages of the controversial part of his work the following expressions, which he applies to the propositions of this consummate thinker in physical and astronomical science: "Incredibly impudent"; "mere twaddle"; "ludicrous explanation"; "admirable for school-children in a go-cart"; "but I see nothing will do but lying, and plenty of it."

Thus, in the "Theory of Color," Goethe remains faithful to his principle that Nature must reveal her secrets of her own free will; that she is but the transparent representation of the ideal world. Accordingly, he demands, as a preliminary to the investigation of physical phenomena, that the observed facts shall be so arranged that one explains the other, and that thus we may attain an insight into their connection without ever having to trust to anything but our senses. This demand of his looks most attractive, but is essentially wrong in principle. For a natural phenomenon is not considered in physical science to be fully explained until you have traced it back to the ultimate forces which are concerned in its production and its maintenance. Now, as we can never become cognizant of forces as forces, but only of their effects, we are compelled in every explanation of natural phenomena to leave the sphere of sense, and to pass to things which are not objects of sense, and are defined only by abstract conceptions.

But this step into the region of abstract conceptions, which must necessarily be taken if we wish to penetrate to the causes of phenomena, scares the poet away. In writing a poem he has been accustomed to look, as it were, right into the subject, and to reproduce his intuition without formulating any of the steps that led him to it. And his success is proportionate to the vividness of the intuition. Such is the fashion in which he would have Nature attacked. But the natural philosopher insists on transporting him into a world of invisible atoms and movements, of attractive and repulsive forces, whose intricate actions and reactions, though governed by strict laws, can scarcely be taken in at a glance. To him the impressions of sense are not an irrefragable authority; he examines what claim they have to be trusted; he asks whether things which they pronounce alike are really alike, and whether things which they pronounce different are really different; and often finds that he must answer, no! The result of such examination, as at present understood, is that the organs of sense do indeed give us information about external effects produced on them, but convey those effects to our consciousness in a totally different form, so that the character of a sensuous perception depends not so much on the properties of the object perceived as on those of the organ by which we receive the information.

We see that science has arrived at an estimate of the senses very different from that which was present to the poet's mind. And Newton's assertion that white was composed of all the colors of the spectrum was the first germ of the scientific view which has subsequently been developed. For at that time there were none of those galvanic observations which paved the way to a knowledge of the functions of the nerves in the production of sensations. Natural philosophers asserted that white, to the eye the simplest and purest of all our sensations of color, was compounded of less pure and complex materials. It seems to have flashed upon the poet's mind that all his principles were unsettled by the results of this assertion, and that is why the hypothesis seems to him so unthinkable, so ineffably absurd. We must look upon his "Theory of Color" as a forlorn hope, as a desperate attempt to rescue from the attacks of science the belief in the direct truth of our sensations. And this will account for the enthusiasm with which he strives to elaborate and to defend his theory, for the passionate irritability with which he attacks his opponent, for the overweening importance which he attaches to these researches in comparison with his other achievements, and for his inaccessibility to conviction or compromise.

In conclusion, it must be obvious to every one that the theoretical part of the "Theory of Color" is not natural philosophy at all; at the same time we can, to a certain extent, see that the poet wanted to introduce a totally different method into the study of Nature, and more or less understand how he came to do so. Poetry is concerned solely with the "beautiful show" which makes it possible to contemplate the ideal; how that show is produced is a matter of indifference. Even Nature is, in the poet's eyes, but the sensible expression of the spiritual. The natural philosopher, on the other hand, tries to discover the levers, the cords, and the pulleys, which work behind the scenes, and shift them. Of course, the sight of the machinery spoils the beautiful show, and therefore the poet would gladly talk it out of existence, and, ignoring cords and pulleys as the chimeras of a pedant's brain, he would have us believe that the scenes shift themselves, or are governed by the idea of the drama. And it is just characteristic of Goethe that he, and he alone among poets, must needs break a lance with natural philosophers. Other poets are either so entirely carried away by the fire of their enthusiasm that they do not trouble themselves about the disturbing influences of the outer world, or else they rejoice in the triumphs of mind over matter, even on that unpropitious battle-field. But Goethe, whom no intensity of subjective feeling could blind to the realities around him, can not rest satisfied until he has stamped reality itself with the image and superscription of poetry. This constitutes the peculiar beauty of his poetry, and at the same time fully accounts for his resolute hostility to the machinery that every moment threatens to disturb his poetic repose, and for his determination to attack the enemy in his own camp.

But we can not triumph over the machinery of matter by ignoring it; we can triumph over it only by subordinating it to the aims of our moral intelligence. We must familiarize ourselves with its levers and pulleys, fatal though it be to poetic contemplation, in order to be able to govern them after our own will, and therein lies the complete justification of physical investigation, and its vast importance for the advance of human civilization.

"*EVOLUTION ADMITTED, WHAT THEN?*"

It is gratifying to note an obvious subsidence of alarm on the part of eminent divines in regard to the acceptance of evolution doctrines, accompanied by the bolder enunciation of rational views respecting religion. Dr. E. O. Haven, Chancellor of the University of Syracuse, and now a Methodist bishop, sends a communication to a leading religious journal under the above title, which is full of significant foreshadowings that are worthy of notice.

Dr. Haven utters a very important truth when he says: "Men are prone to associate their religion with its drapery. This becomes obsolete and must be changed, and the looker-on fancies that the very body and soul are gone." This is the view of science. Religion, like other things, is progressive, and proceeds from stage to stage, successively molting its integuments with increasing expansion and a higher life, or, by the figure of Dr. Haven, shedding its worn-out clothing as occasion requires. It is a great point gained in this matter to discriminate between the living body and its accidental and temporary wrappings—between perennial truth and its obsolete accompaniments. The credal habiliments are not the vital thing they invest, and to cling to them as if they were is superstition. Dr. Haven's point of view enables us to appreciate the triviality of denominational cuts, fits, and styles; and illustrates the futility of venerating theological rags and tatters instead of the essential religious ideas which require ever to be clothed anew as men grow in grace. And what a pitiful spectacle, moreover, it is to see people so confused and perverted in their notions as to actually worship the heaps of old clothes that have been long ago worn out and cast off!

We are glad to observe that Bishop Haven does not recoil from the conception of creation as a continuous, ever-unfolding work. He wisely accepts the view of God, compelled by evolution, as that of an eternally-creating Spirit. He says, "Is there any reason whatever to believe that God at any past period, large or small, had any more or less to do than now with this earth and all that it contains?" And again: "Had we all been educated in a theory of gradualism and constancy and improvement, and thoroughly saturated with it, and yet aroused into a profound belief in God, as is certainly conceivable on that theory, and then, should the theory of a Deity sometimes awake and sometimes asleep be suggested, it would shock some feeble minds into atheism." But would not strong minds also be thus shocked, and justly so; and would not the atheism be real? When evolution has become an established and familiar idea in the religious world, and the Creative Power is conceived—as far as such conception is possible to finite faculties—as the mighty, ever-energizing spirit of which the boundless universe is but the manifestation, a reversion to present current notions of the method of creation will assuredly be regarded as a lapse into atheistic paganism, analogous to a present backward plunge into fetichism.

LITERARY NOTICES.

Preadamites; or a Demonstration of the Existence of Man before Adam; together with a Study of their Condition, Antiquity, Racial Affinities, and Progressive Dispersion over the Earth. With Charts and other Illustrations. By Alexander Winchell, LL. D., Professor of Geology and Paleontology in the University of Michigan. Chicago: S. C. Griggs & Co. Pp. 500. Price, $3.50.

The views of Dr. Winchell on the subject of preadamites, which he put forth some time ago in a modest pamphlet, to which we drew attention, he has now matured and brought out in a very handsome and richly illustrated volume. We have been more than pleased with a somewhat critical perusal of it. The work is popular in its best sense—attractive in style, clear in exposition, and eminently instructive in its subject matter. Though drawing its facts from wide sources, it is far from being a mere compilation; it is dominated by a large, original purpose, which is kept steadily in view throughout the whole course of its close and trenchant argument.

Dr. Winchell's book has a double interest which should not be overlooked. Though making no claims of this nature, it is yet a valuable exposition of ethnological science, treating instructively a wide range of questions in relation to the origin, distribution, characteristics, and natural history of the human races. These subjects are now of commanding interest. All modern knowledge converges upon this great human research; and "the proper study of mankind" is now more fruitful of positive and pregnant conclusions than it has ever been before. The theme is itself of intrinsic moment to the students of nature, and is engaging the assiduous attention of talented men in all cultivated nations. From this point of view alone, or as a repository of facts and a lucid exposition of principles, the volume has marked merit, and will do excellent service simply as a popular ethnological manual.

But, while useful as a mere didactic discussion of anthropological questions, the work has an interest of another kind in relation to the special object for which it was written. It is an able contribution to a serious modern controversy, which will bring it into demand beyond the customary circle of scientific and miscellaneous readers. The Church has its traditional ethnology, vaguely assented to by multitudes who have never inquired into the subject, but which is now totally out of harmony with all the results of actual knowledge. It is the old astronomical conflict over again, in a more modern field. Knowledge still advances, and stationary, dogmatic beliefs are left standing as milestones to mark its progress. The prevalent ecclesiastical theory of the origin and history of the human race, which is passively entertained by the great body of orthodox believers, must be discarded or squared with the results of scientific investigation. All fair-minded theologians will recognize the significance of the crisis, and welcome every efficient contribution toward the settlement of the difficulty. Dr. Winchell's work is devoted to this object, and it is executed with such learning and ability that it must at once take rank as an authoritative text-book of the subject. It is not too much to say that it settles the controversy; and all Christian teachers, who have any genuine interest in the adjustment of their beliefs so that they shall harmonize with scientific demonstrations, owe gratitude to the author of this work for the untiring labor that he has bestowed upon the inquiry, and the intrepid spirit in which he has pursued it.

The definite scope of Dr. Winchell's book may be best obtained from his own statement. He says: "The central idea of the work is human preadamitism; all other views presented are subsidiary or collateral. The thesis implies that the characterization of Adam, in the document which has given us the name, is such that the name can not be applied to the first progenitor of the human kind, and that all the collateral statements either involve or permit the derivation of Adam from an older race. But the defense of the thesis does not rest, as it once did, on the purely linguistic interpretation of the Bible. We have now the facts of race-histories, and the discovered laws of animal life, past and present, to summon to the sanction and support of the conclusion. I have not contented myself with the employment of the direct argument, but have attempted to show that the old hypothesis of the descent of the black races from Ham is equally unscriptural and unscientific. Finally, assuming the thesis proved, I have endeavored to gratify the natural and intelligent curiosity which expresses itself in the questions: Who, then, were the first men? Where did they appear, and how long since? How have the races come into existence, and what has been the method of their dispersion over the earth? These questions necessarily lead us to the very borders of the field of recognized facts, and even into the domain of speculation; but I hope I have in most cases presented views which coördinate the facts in a rational conception, if I have not enunciated conclusions which will stand the test of future investigation. I hope, also, that on some of these themes I have presented groupings of the facts and tentative generalizations which will interest the strictly scientific inquirer. In any event, I desire the reader to consider that the defense of the main thesis is not involved in any of the hazard of the speculative suggestions brought forward in the sequel."

It is impossible here to enter into any detail of the views developed in this work; but the reader will get a good idea of the nature and breadth of the discussion by an ennumeration of the subjects treated. Dr. Winchell's chapters are: I. "Some Traditional Beliefs"; II. "Biblical Language"; III. "The Hamites and their Dispersion"; IV. "The Semites and their Dispersion"; V.

"The Japhetites and their Dispersion"; VI. "Principal Types of Mankind"; VII. "Limited Scope of Biblical Ethnography"; VIII. "A Glance at Hebrew Chronology"; IX. "Elements of Egyptian Chronology"; X. "Prenoachite Races"; XI. "Race Distinctions"; XII. "Biblical Antiquity of Race Distinctions"; XIII. "More Biblical Antiquity of Race Distinctions"; XIV. "Preadamite Races"; XV. "Hamitic Origin of Negroes considered"; XVI. "Negro Inferiority"; XVII. "Do Races degenerate?"; XVIII. "Theological Consequences of Preadamitism"; XIX. "Genealogy of the Black Races"; XX. "Genealogy of the Brown Races"; XXI. "Genealogy of the White Race"; XXII. "The Cradle of Humanity and the Dispersion of the Black Races"; XXIII. "Dispersion of the Asiatic Mongoloids"; XXIV. "Dispersion of the American Mongoloids"; XXV. "Dispersion of the Dravidians and Mediterraneans"; XXVI. "Condition of Primitive Man"; XXVII. "Antiquity of Man"; XXVIII. "The Patriarchal Periods"; XXIX. "Preadamitism in Literature."

Dr. Winchell's book is got up in elegant form. It contains a large number of beautifully executed illustrations, with some finely worked charts. Press-work and binding are in the best style, doing credit to the enterprise of the publisher and to the proficiency of industrial art in the city where it was produced.

The Life and Writings of Henry Thomas Buckle. By Alfred Henry Huth. New York: D. Appleton & Co. Pp. 502. Price, $2.

Though the career of Buckle was not filled with striking incidents, such as are commonly supposed to be necessary to give interest to biography, it was, nevertheless, of so marked and individual a character that its delineation is certain to prove both instructive and entertaining to a large number of readers. Whatever may be the final verdict as to the value of his intellectual work, Buckle was certainly a power in the thought of his time—a man of force, originality, and independence, so conspicuous as to give significance to the personal particulars of his life. There was much curiosity about him as to who he was, and what had been his history, when he suddenly shot up from obscurity to a brilliant position in literature, and various sketches of him were called forth at the time, although they were meager and unsatisfactory. This volume is the first extended biography of Buckle that has appeared; and, although his intimate friend, Mr. Huth, writes as an ardent admirer, he has endeavored to make a just estimate of his character as a man and a thinker. The volume derives large interest from the considerable correspondence which it reproduces, and which throws much light on the habits, peculiarities, and opinions of the man. Mr. Huth makes an excellent summary of the leading conceptions of Buckle's work, pointing out what seem to be the fundamental conceptions that are due to him, and which it is claimed have largely contributed to place history in the category of the sciences. It may be freely conceded, at any rate, that he did a great service in presenting this view in so captivating a style, and with such a wealth of illustrations, as to make a profound impression upon the popular mind. His "History of Civilization in England" was a liberalizing book, and exerted an educating influence upon multitudes of readers.

Like many other men who have achieved a position and done valuable work, Buckle's early education was out of the common routine which more often cramps than develops. He was, in fact, allowed to do pretty much as he desired with regard to study, and was, therefore, free to follow his own bent. His individuality was but little interfered with, and he was left to the best of all culture—self-culture. The death of his father, when he was but nineteen years of age, left him in easy circumstances, with leisure to pursue his studies in the direction of his chosen life-work. The idea of the history was at first vague in his mind, and grew into more definite shape with advancing years. While yet without experience of the formidable labor before him, he drew up the most ambitious schemes of the history of civilization which he proposed to execute in a series of twenty volumes, but he died at the early age of forty-one, with only a fragment of his great design accomplished. It was a noble purpose to which he consecrated his life, and even in its very partial attainment he made a contribution to historic inquiry which has been translated into many languages, and influenced in no small degree the thinking of his generation.

Mr. Buckle was, beyond doubt, deficient in many qualities necessary to handle so vast a theme at the period when he entered upon the undertaking. He lacked the scientific preparation for dealing adequately with his task. He was not well equipped with the large ideas which had a bearing upon it, and which were already ripened in leading contemporary minds. When he published his first volume, in 1857, Herbert Spencer had already matured a system of thought, involving the principles of social development, and based upon the new philosophy of evolution. Mr. Buckle was not only unprepared to avail himself of these controlling conceptions, but he resisted some of them as he would not have done if his training had been more thoroughly in the true spirit of science. But he did his work well, and it is fortunate for his memory that the task of delineating his life fell into such excellent hands as those of his present biographer. The book is interestingly written, and will be read with pleasure even by those who know little of the works of the author.

The Fundamental Concepts of Modern Philosophic Thought, critically and historically considered. By Rudolph Eucken, Ph. D., Professor in Jena. Translated by M. Stuart Phelps, Ph. D., with an Introduction by President Porter. New York: D. Appleton & Co. Pp. 304. Price, $1.75.

Professor Eucken's book is not only an important addition to the history of philosophy, but it is an addition that is specially adapted to the requirements of the present time. With great skill and learning, and remarkable clearness of style for a German philosopher, he has traced out the origin and progress of those fundamental conceptions which play so prominent a part in modern controversy, and also of the terms by which those ideas are represented. The author's point of view is tacitly that of evolution, since he undertakes to delineate the philosophical concepts of to-day in their historical formation, and in their transformations, extensions, and shiftings of phraseology. How fitly his discussion answers to the needs of the times will appear from a glance at the contents of his volume, which we subjoin: I. "Subjective and Objective"; II. "Experience"; III. "A Priori—Innate"; IV. "Immanent (Cosmic)"; V. "Monism, Dualism"; VI. "Law"; VII. "Development"; VIII. "Primary Concepts of Causation (Mechanic—Organic) (Ideology)"; IX. "Culture"; X. "Individuality"; XI. "Humanity"; XII. "Realism—Idealism"; XIII. "Optimism—Pessimism"; XIV. "Conclusion."

It will be seen from this enumeration of subjects that the work covers a large field of contemporary interest, both scientific and speculative; but it must not be supposed that the author engages in the positive discussion of these topics as they are now treated by systematic controversialists. Into the present conflict of thought, as the representative of any school, he does not enter; and hardly a great name in the science or philosophy of the present age appears in his pages. But, taking the leading conceptions that are now of special interest in literary and philosophical circles, and which, "proceeding from philosophy and the general scientific development, have become a power in life as a whole," he subjects them to such historical analysis and criticism as will prove serviceable to the modern student.

Dr. Porter recommended this volume for translation, and has at once adopted it as a text-book in Yale College. He contributes to it a brief Introductory Essay, commending it to English readers as eminently suited to the times. "He can say with an assured confidence that there are few books within his knowledge which are better fitted to aid the student who wishes to acquaint himself with the course of modern speculation and scientific thinking, and to form an intelligent estimate of most of the current theories."

Chemistry, Inorganic and Organic, with Experiments. By Charles Loudon Bloxam, Professor of Chemistry in King's College, London. Fourth edition. Philadelphia: Presley Blakiston. Pp. 688. Price, $4.

Bloxam's "Chemistry" has had an excellent reputation as a practical manual for several years; and the present revised edition brings it fairly up to date. The author remarks that some alterations have been made in the present edition, to bring the theoretical portion into harmony with modern views; but its treatment of chemical theory, although good, is not the strongest feature of the work. Its first claim to consideration, and an important one, is the great number of simple illustrative experiments that it pictures and describes. There is a great profusion of cuts representing apparatus and manipulations, which will be most serviceable to lecturers and chemical workers. Another point of special interest in the work is the prominence it gives to the subject of manufacturing processes. The principles involved in the most important of these are very clearly and fully explained. Professor Bloxam has been long associated with the Government military establishment at Woolwich, and has made many investigations into the properties of explosives. The student will accordingly find that more than usual attention is given to the chemistry of the various substances employed in warlike stores.

Pharmacographia: A History of the Principal Drugs of Vegetable Origin met with in Great Britain and British India. By Friedrich Flückiger, Ph. D., Professor in the University of Strasburg, and Dan. Hanbury, F. R. S. Second edition. London: Macmillan & Co. (22 Bond Street, New York). 1879. 8vo, pp. 803. Price, $5.

The second edition of this master-work, first published in 1874 and now revised by the only surviving author, Professor Flückiger, has been long looked for, and is received everywhere with due appreciation. Exceeding the first edition by one hundred pages, it is identical with it in scope and arrangement. The drugs are classified according to their botanical origin, and the natural orders arranged in accordance with the system of De Candolle. The Latin name, with the principal synonyms of each drug, is followed by their English, German, and French names. The main sections of each article treated are: "Botanical Origin," "History," "Collection," "Description," "Microscopic Structure," "Chemical Composition," "Production and Commerce," "Uses, Adulterations, and Substitutes."

The section "Botanical Origin" enumerates the recognized botanical name, together with the synonyms, the habit, and locality of the plant yielding the drug; all strictly botanical descriptions are, very properly, almost entirely excluded. The section "History" is particularly unique and interesting; it gives an historical account of each drug from the time when it was first used, traces its employment by different nations, its influence upon commerce, its value at different periods, cultivation, etc. This is followed by an account of the "Collection" of the drug, and its manufacture for the market, in all such cases where this information is likely to explain its physical properties, which are described under the section "Description," and followed by "Microscopical Structure." In the section "Chemical Composition" the views of different investigators have been carefully sifted, and the results of the most recent researches given. Interesting and valuable information and statistics are found in the division "Production, Cultivation, and Commerce." The section "Adulteration and Substitutes" is brief, since the surest way to detect adulterations, of whatever kind, is to be found in a sufficient familiarity with the leading characteristics of the pure article.

The value of all this information is much enhanced and made specially attractive and interesting by copious reference to original sources, covering a wide and varied scope of both old and recent literature.

If there is any desideratum which the very value of the work suggests, it is the want of illustrations in the sections of "Description" and "Microscopical Structure," for which the authors thus far refer to several standard works, mainly German ones, and which desideratum has been well met in the French translation of the work by Professor de Lanessau, which contains more than three hundred well-executed cuts.

An Introduction to the Philosophy of Religion. By John Caird, D. D. New York: Macmillan & Co. Pp. 358. Price, $3.

A disquisition upon this subject by the Principal of Glasgow University is sure to have a wide welcome. Dr. Caird is well known as one of the clearest and soundest thinkers of the conservative school of theology. In calm, philosophic temper, in liberality of thought, and in acuteness and force of reasoning, this work is far above the class to which it belongs, and of which we have had many examples within the last few years. The progress of science gives Dr. Caird no anxiety. He cordially accepts its advanced conclusions, and is not concerned about any modification they may necessitate in the old formulas of belief. He perceives that the issues in which religion is essentially involved lie deep in the foundations of psychology, in the nature of knowledge, and the limits of the knowing faculties; and he accordingly addresses himself to a close, logical examination of this subject. There is nothing flippant in his treatment of it; no bad temper, no abuse, no invective, nothing for controversial effect. He sets an example which many of his brethren would be wise to follow, and we accordingly commend his work.

The Watering-Places of Germany, Austria, and Switzerland, Climatic Resorts, Sanitariums, etc. By Edward Gutmann, M. D. New York: D. Appleton & Co. 1880. Pp. 331. $2.50.

The author and publishers of this book deserve the thanks of all those who seek health and recreation at the European watering-places. In language easily understood by all, Dr. Gutmann, who is a resident of New York, has described the medicinal properties of the different waters, whether for bathing or drinking, so that the intelligent reader may clearly perceive not only why he is to visit a particular watering-place, but also how he is to enter upon his treatment when he arrives there, and in what way the restoration of health may be most certainly and quickly attained. Nor has the very important matter of diet and manner of living at the watering-places been forgotten, and ere the patient arrives at his destination he can, by the perusal of this book, which is entertaining as well as instructive, acquaint himself with those rules of life and diet which long experience has shown to be so necessary to insure the full benefit of the treatment. In fine, the stranger is made so well acquainted with the place he is to visit, with its history, its baths and springs, its mode of life, and even its appearance, that he feels himself soon at home, and free from that disagreeable sensation so often experienced by the stranger in a strange land. There is a map on which all the different places mentioned in the book are clearly indicated, as well as the routes by which they may be reached from any of the great European cities, or from each other. Each bathing and watering place has also the character of its springs indicated by a colored line, so that the traveler may see at a glance the nature and properties of the waters of any given place: for instance, the blue line indicates the alkaline; the green, the saline; the yellow, the sulphur; the orange, the iron; the brown, the earthy; and the red, the indifferent waters; while the climatic resorts are indicated by a violet line. In short, with this book in hand, the seeker after health may start from New York, London, or Paris, and, with no other guide, reach easily and safely the proper resort for his ailment, and upon his arrival there be fully prepared to enter intelligently upon the course of diet and treatment. There is a comparative table of the different moneys in use in the countries to be visited, as well as a carefully compiled analysis of the different waters. A most useful feature, too, is the therapeutical recapitulation, in which the author briefly indicates the special uses of the different waters, and cures for the alleviation of the ailments for which they have gained a well-earned reputation. The book is handsomely illustrated by engravings of the principal places mentioned, and is a credit to its publishers as well as to its author, who brings to his work the knowledge gained by years of travel and experience, and an entire familiarity with the places of which he treats. To the physician who has patients to send abroad the book is a valuable aid, and to the invalid seeking health at the European spas it is indispensable.

Life: Its True Genesis. By R. W. Wright. New York: G. P. Putnam's Sons. Pp. 298. Price, $1.50.

A vigorous orthodox polemic against the "materialist school." It contains much ingenious criticism of modern scientific doctrines, but we are unable to see that it throws much new light on the "True Genesis of Life." It is much easier to show the folly and absurdity of the views put forward by Darwin, Spencer, and others, than to bring forward new theories that shall not be open to criticism.

A Handbook of Hygiene and Sanitary Science. By George Wilson, M. A., M. D., and C. M. (Edin.), F. C. S. Fourth edition. Philadelphia: Lindsay & Blakiston. 1880. Pp. 458. Price, $2.75.

In issuing a fourth edition of his valuable work on hygiene, Dr. Wilson has carefully revised the book and enlarged it by some new matter. A new introductory chapter, giving a brief sketch of the progress of sanitary science, has been substituted for that in the previous editions. The work considers a large number of subjects, giving the latest and most authentic knowledge in an interesting form.

The subject of food is considered very fully with regard to its function, constituents, nutritive value, relation to work, and its effects upon public health when it is insufficient or unwholesome. Under this head are also considered the value of preserved foods, the comparative value of different kinds of food, and the construction of dietaries. Air, its impurities and their effects upon public health; the conditions of warming and ventilation; water and its impurities, sources of pollution and modes of detection; the removal of sewage, its purification and utilization; together with a large amount of other matter bearing upon the general question of healthy living, make up the contents of this very excellent treatise. Dealing with subjects of such prime importance to the family, it should find a place in every household.

A Handbook of Double Stars. With a Catalogue of Twelve Hundred Double Stars, and Extensive Lists of Measures. With Additional Notes bringing the Measures up to 1879. For the Use of Amateurs. By Edward Crossley, F. R. A. S.; Joseph Gledhill, F. R. A. S.; and James M. Wilson, M. A., F. R. A. S. New York: Macmillan & Co. Pp. 464. Price, $6.

This work is intended to facilitate the labors of future students of sidereal astronomy, by supplying the materials for the study of double stars in a convenient form, and as complete as its painstaking authors could make it. It has arisen out of their wants as students, as there does not exist any other book which gives information sufficiently detailed to be of value to any one who seriously takes up this study. The student must hunt through scores and hundreds of volumes if he wishes to get an accurate and complete list of the previous measures of any particular double star. These measures are scattered up and down the astronomical periodicals of all nations; and if he desires to know with what instruments, with what apertures, and what micrometers, these measures were taken, a fresh research awaits him. And, if he proceeds to attempt an orbit, he will fail unless he is a tolerably expert mathematician, for want of sufficient guidance and detail in the various mathematical papers and pamphlets that have been devoted to this subject. The authors express the hope that this manual will be of use in guiding amateurs in their work, in pointing out what stars are of especial interest, what stars have had few or conflicting measures taken of them, at what times observations of certain stars are especially needful, and what stars have been so frequently and satisfactorily measured that for the present they need no attention. The work is appropriate to the present time, as there has been great activity in this field of observation during the last six or seven years. It embodies the results of an immense amount of careful and accurate labor, and can not fail to be of much use to practical astronomers.

Pay Hospitals and Paying Wards throughout the World. By Henry C. Burdett. Philadelphia: Presley Blakiston. 1880. Pp. 169. Price, $2.25.

This is a consideration of the hospital systems of the world, with a view to showing the advantages of pay hospitals and pay wards in general charitable hospitals. In England the system is to have only charitable hospitals, and this results in depriving large classes of the great advantages of a well-appointed medical institution, while it at the same time allows many, who can afford to pay for treatment, to obtain it gratuitously. Mr. Burdett states that from thirty to sixty per cent. of those who receive out-door relief are not fit subjects for charity, while a smaller but still considerable percentage of those who are treated within a hospital belong to the same class. He thinks that a stricter inquiry should be made into the circumstances of those applying for charitable relief, confining the advantages of such institutions to the really needy; and that for the accommodation of all others pay wards, or separate pay institutions, should be provided. He makes a review of the hospitals working successfully on this basis in other countries, to show both the feasibility and desirability of such institutions in England.

A Key to Ghostism: Science and Art unlock its Mysteries. By Rev. Thomas Mitchell. New York: S. R. Wells & Co. Pp. 249. Price, $1.25.

The author of this volume professes to discredit the supernatural element of modern spiritualism, and to explain all its effects naturally. He holds to clairvoyance and animal magnetism, and accounts for everything of the kind by those agencies. There does not seem to be much gained. Of the science of the book we can not speak very highly. A story is told of a woman suspended horizontally in mid-air, with her head resting upon her arm, and her arm resting upon the the top of a rod. "The lady weighs about one hundred and thirty pounds; and, while thus suspended, the attraction of gravitation is completely overcome. Were the rod upon which her head rests fastened into a scale, she would not probably weigh twenty pounds." Indeed, it is declared that all supports have been removed, "and she left hanging in the air without touching an object; in which case, of course, she would weigh nothing. . . .

"The science of this phenomenon we have already explained. Gravity consists in the attraction of the atmosphere to the earth, and by it. This is called atmospheric pressure, which is fifteen pounds to the square inch. The bulk and density of the earth being so much greater than those of the atmosphere, give all bodies on its surface this superior attractive force to the earth. . . .

"In order to suspend this woman, it was necessary to charge her with electricity or magnetism, fifteen times higher than that of her normal condition. This makes her as positive as the earth itself; and, as two positives resist each other, she hangs in the air just where she is placed. Now, if she should be charged higher than this degree, say sixteen pounds to the square inch, she would, of herself, without a touch, rise from the floor to the ceiling, or to that locality where she would be in equilibrium with the attractive force of the air; and, until demagnetized, would there remain suspended."

And of such is the "Key to Ghostism."

Common Mind Troubles, and the Secret of a Clear Head. By G. Mortimer-Granville, M. D. Edited, with Additions, by an American Physician. Philadelphia: D. S. Brinton. Pp. 185. Price, $1.

This volume is a reprint of two English primers dealing with kindred topics, which may very well go together. There are many valuable hints in it regarding the care and management of the mind, but the author seems foolishly nervous lest somebody should take him for a materialist. As the main practical facts are independent of speculation, why should he take pains to put himself forward as a theorist and a partisan? Dr. Granville, however, has given much attention to the subject of mental diseases.

Dwelling-Houses: their Sanitary Construction and Arrangement. By Professor W. H. Corfield, A. M., M. D. Van Nostrand's Science Series. New York: D. Van Nostrand. Pp. 156. Price, 50 cents.

This is a small volume of lectures reprinted from "Van Nostrand's Magazine," which will well repay attention to those concerned about the hygiene of house-construction. The subject is of deep and increasing interest; Professor Corfield is an authority upon it, and he is content with a plain, common-sense statement of the subject. His lectures refer to English practice, but the principles he expounds are applicable everywhere, and if followed in this country would be productive of much advantage both private and public.

Our Homes. By Henry Hartshorne, A. M., M. D. Philadelphia: Presley Blakiston. 1880. Pp. 149. Price, 50 cents.

This is one of the series of "American Health Primers" and is an excellent and concise statement of the conditions to be fulfilled in order to have a healthy home. The subjects considered are the site, the construction of the house, the means of lighting, warming, and ventilating it, and the water supply, drainage, and disinfection. There are also short chapters upon the population that, from a health point of view, should live in any given space, and on workingmen's homes.

PUBLICATIONS RECEIVED.

The Microscopical Investigations of the Havana Yellow Fever Commission. By George M. Sternberg, Surgeon U. S. A. New Orleans: S. Graham, Printer. 1880. Pp. 7.

Report of the State Engineer of California. Sacramento: State Printing-Office. 1880. Pp. 518.

Modern Abuse of Gynæcology. By Clifton E. Wing, M. D. Boston. Pp. 8.

Effects of Mixture of Races on Human Progress. By Professor Joseph Le Conte. Reprint from "Berkeley Quarterly." 1880. Pp. 24.

Quarterly Report of the Chief of the Bureau of Statistics for the Three Months ending December 31, 1879. Washington: Government Printing-Office. 1880.

The Sulcus Rolando and Intelligence. By S. V. Clevenger, M. D. Illustrated. Chicago: J. J. Spalding & Co., Printers. 1880. Pp. 23.

Interstate Extradition. By J. M. Kerr. St. Louis: G. J. Jones & Co. 1880. Pp. 22.

Astronomical Approximations. IV. Nodal Estimation of the Velocity of Light. V. Cometary Paraboloids. VI. Cosmical Determination of Joule's Equivalent. By Pliny E. Chase, LL. D., Professor of Philosophy in Haverford College.

Caries of the Ankles in Children. By V. P. Gibney, A. M., M. D. New York: W. Wood & Co. 1880. Pp. 26.

The "North American Entomologist." Edited by Professor A. R. Grote. An Illustrated Monthly for the Use of Students and Agriculturists. Buffalo, N. Y.: Reinecke & Zesch. Pp. 8. $2 a year.

The Masterful Ego, or Mind considered from a Purely Physical Standpoint. By W. D. Wilson. Ithaca: Andrus & Church. 1880. Pp. 8.

The Recession of the Falls of St. Anthony. By N. H. Winchell, State Geologist of Minnesota. Pp. 16. Illustrated.

Address of Professor S. P. Langley, Vice-President Section A., before the American Association for the Advancement of Science, at the Saratoga Meeting, August, 1879. Salem, 1879. Pp. 15.

Cerebral Topography. By S. V. Clevenger, M. D. Reprint from "Journal of Nervous and Mental Disease," October, 1879. Pp. 27.

Report of the Board of Commissioners of the Seventh Cincinnati Industrial Exhibition, 1879. Cincinnati: "Times" Printing Establishment. 1880. Pp. 408.

Proceedings of the Davenport Academy of Natural Sciences. Vol. II., Part II. July, 1877–December, 1878. Davenport, Iowa: J. D. Putnam. 1880. Pp. 356. Illustrated.

Twelfth and Thirteenth Annual Reports of the Trustees of the Peabody Museum of American Archæology and Ethnology. Vol. II. Nos. 3 and 4. Cambridge, 1880. Pp. 311. Illustrated.

The Coming Crisis. San Francisco: A. L. Bancroft & Co., Printers. 1879. Pp. 136. $1.

Problems in Relation to the Prevention of Disease. By J. R. Weist, A. M., M. D. Annual Address of the President of the Indiana State Medical Society. Richmond, Indiana: Telegraph Printing Co. 1880. Pp. 25.

Our Home: a Monthly Magazine. New York: George H. Bladworth & Co. No. 1. January, 1880. Pp. 28. $1 a year.

Heveenoid; the Rubber of the Future. By H. A. Mott, Jr., Ph. D. New York: Trow Printing Company. 1880. Pp. 13.

Eighth Annual Report of the Directors of the Zoölogical Society of Philadelphia. Philadelphia. 1880. Illustrated. Pp. 37.

Thirteen Papers in Support of Mr. Helper's Scheme for constructing a Longitudinal Double-Track Steel Railway through North and Central and South America. St. Louis: W. S. Bryan. 1880. Pp. 24.

Hygienic and Therapeutic Relations of House Plants. By J. M. Anders, M. D., Ph. D. Philadelphia: Printed by J. B. Lippincott & Co. 1880. Pp. 16.

"On the Ghosts in Rutherford's Diffraction-Spectra," and "A Quincuncial Projection of the Sphere." By C. S. Peirce. Reprinted from the "American Journal of Mathematics," Vol. II. 1879.

"Note on the Theory of the Economy of Research," and "Measurements of Gravity at Initial Stations in America and Europe." By C. S. Peirce. Appendices Nos. 14 and 15 to "United States Coast Survey Report of 1876." Washington: Government Printing-Office. 1879.

Multiplication and Division Table, containing the Products of Numbers between 1 and 100. For the Use of Accountants, Computers, and Teachers. By Leonard Waldo, S. D. New York: John Wiley & Sons. 1880.

The Management of Children in Sickness and in Health. By Anne M. Hale, M. D. Philadelphia: Presley Blakiston. 1880. Pp. 110. 50 cents.

The Morals of Evolution. By M. J. Savage. Boston: George H. Ellis. 1880. Pp. 191. $1.

The Fabulous Gods denounced in the Bible. Translated from Selden's "Syrian Deities." By W. A. Hauser. Philadelphia: J. B. Lippincott & Co. 1880. Pp. 178. $1.25.

The Metric System. By D. Beach, Jr., and E. A. Gibbens. New York: G. P. Putnam's Sons. 1880. Pp. 62. 75 cents.

The Throat and its Functions. By Louis Elsberg, A. M., M. D. Illustrated. New York: G. P. Putnam's Sons. 1880. Pp. 60. $1.

Eminent Israelites of the Nineteenth Century. By Henry S. Morais. Philadelphia: Edward Stern & Co. 1880. Pp. 371. $2.

Health and Healthy Homes: A Guide to Domestic Hygiene. By George Wilson, M. A., M. D. With Notes and Additions, by G. J. Richardson, M. D. Philadelphia: Presley Blakiston. 1880. Pp. 307. $1.50.

The Field Engineer: A Handy-Book of Practice in the Survey, Location, and Track-work of Railroads. By William F. Shunk, C. E. New York: D. Van Nostrand. 1880. Pp. 325. $2.50.

Hints and Helps for National Guardsmen. By Colonel William H. Roberts. New York: D. Van Nostrand. 1880. Pp. 228. $1.25.

A Practical Treatise on Sea-Sickness. By George M. Beard, M. D. New York: E. B. Treat. 1880 Pp. 74. 50 cents.

Water Analysis for Sanitary Purposes. By F. Frankland, F. R. S. Philadelphia: Presley Blakiston. 1880. Pp. 149. $1.

The Hysterical Element in Orthopædic Surgery. By Newton M. Shaffer, M. D. New York: G. P. Putnam's Sons. 1880. Pp. 66. $1.

POPULAR MISCELLANY.

The Sanitary Problems of New York City.—Professor W. P. Trowbridge, discussing "The Sanitary Problems of New York City," in the "School of Mines Quarterly," considers chiefly the ventilation of houses and the condition of the streets. The topography of the city, presenting long rows of closely built blocks of dwellings and stores, and of the narrow streets that separate them, is a very obvious sign of the close crowding of a large population into a small space which actually exists. This crowding is of itself a great sanitary evil. If, says Professor Trowbridge, we may take a lesson from nature in the distribution of other classes of the animal kingdom, we find that the herding together in confined places of any one class of animals is detrimental to the health and well-being of the individuals. Diseases peculiar to the class of animals are apt to arise, and a general physical deterioration takes place. "As an animal, man is not exempt from this law of nature, unless, through his own superior intelligence, he secures to himself immunity from the evils which over-crowding entails." A momentous question in our city life is whether, in the construction of our houses, and stores, and hotels, and public halls, the quantity of air which each person requires for his health is provided for by processes or appliances of ventilation. The quantity of air required for a healthy life is generally estimated by the number of cubic feet needed for respiration alone. This is a mistake. Each person needs vastly more—enough to secure a thorough aëration of his clothing and to destroy by oxidation all the hurtful emanations of the body. In houses, moreover, the needs of large quantities of pure air for the aëration of clothing, basements, kitchens, closets, and the closets in which clothing is kept, are probably as great as for respiration. Yet, "how few of the houses in the long blocks which constitute the city of New York have been constructed with the slightest reference to the constant introduction and removal of air!" All of our houses are provided with four or five chimney-flues which might be made available for ventilation to a certain extent, but in the use of which it is so little thought of that the rooms, that might be connected with them, are hermetically sealed from them. The kitchen or basement, where there is necessarily an accumulation of deleterious gases, or impoverished air, is perhaps the worst ventilated room in the house. The people still need to be convinced that ventilation is necessary, and that force must be used to move the air. The object can be secured by means of vertical ventilating flues of sufficient suction, but the application of heat either by a gas-jet or other artificial means is requisite to keep them in operation. The matter of the dirt in the streets has an important sanitary aspect. From this point of view, Professor Trowbridge thinks it is worthy of consideration whether an entirely new treatment is not advisable. Heretofore, attention has been confined to the removal of the dirt as it accumulated; Professor Trowbridge would have means adopted to prevent its accumulating. "The dirt that covers the streets as they are now paved does not come entirely from above or from any external source, but is forced upward from beneath the pavements by the impact of the trucks, carts, carriages, and horses' hoofs, in the ordinary traffic of the city. It is doubtful whether it is possible to keep the streets reasonably clean, even with an expenditure of double the present outlay for that purpose. The soil on which the pavements are laid is not a soil which effects its own drainage, and each successive shower or storm saturates the surface beneath the paving, the water carrying down the leachings of the streets; and this soil, permeated with decomposing substances and saturated with polluted water, is forced to the surface. No better medium for retaining and giving off malarial gases could probably be manufactured. When dried, this expelled mud becomes dust, and is carried about by the winds into every household. The real cure of this great evil appears to me to be an impervious pavement — an asphaltic pavement." No dirt could rise through this, and, if every street in the city were paved with it, what dirt falling upon it was not carried off naturally by showers into the sewers could be thoroughly removed by mechanical sweepers without dust or noise.

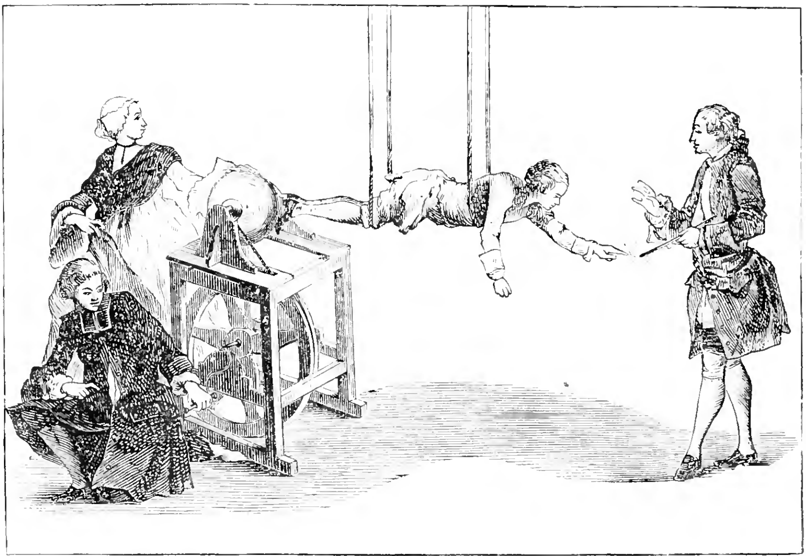
The resulting purity of the surface of the streets would have an excellent æsthetic effect upon the population, particularly on those who live in the dirty streets, and would prompt them to purify their own homes, make them pleasant and adorn them —works from which they are now discouraged by the public filth that surrounds them, and which they can not help. Other sanitary improvement would follow the general adoption of these pavements, in the relief from nervous disorders which would be gained by the cessation of the noise of the stone pavements and the worry from their dust and joltings. "The time has come when the sanitarian must extend his field even beyond mere physical causes of disease, and look to the palliation of the effects of incessant struggles and conflicts which a business man of the present day must undergo. . . . Quieting influences are worth almost any price, and these should be sought and provided along with those which relate to physical health."

Origin of Domestic Dogs. — Professor Huxley, in the second of two lectures on dogs which he recently delivered at the Royal Institution, examined the peculiarities of the animals of the dog kind, and pointed out that the only respect in which the varieties presented any very great or remarkable difference, apart from the color of the skin or fur and other minor details, was in the structure of the skull and in the teeth. The form of dog which departed most widely from the rest in its dentition was the octocyon, a small, fox-like creature belonging to South Africa, which had forty-eight teeth, while other dogs had forty-two. The dog-like animals might be divided into two classes according to the peculiarities of the skull—those like the wolf, or the thooids, having a great cavity over the brow which causes the front to be prominent; and those like the fox, or the alopecoids, which are without this cavity. This enabled them to fix the position of the domestic dogs still more definitely; it would occupy a place in the series corresponding with that in which they had put the jackals and wolves. With regard to the stag-hound, the shepherd's dog, and many of the cur-dogs, no one would have the slightest hesitation in placing them just between the wolf and the jackal. Some domestic dogs had as large a development of skull as the wolf, but the appearance of sagacity it gave them could not be depended upon, for it was often due to the existence of the cavity. Speculating upon the probable origin of the domestic dog, Professor Huxley called attention to the fact that, in Northwest America, the Indian dog was not really distinguishable from the prairie-wolf. The domestication of these animals was easily explicable when it was remembered that, although fierce enough when stirred up, they were endowed with singular curiosity, which attracted them particularly toward man and his doings, and that, when caught young and kindly treated, they soon became as attached and devoted to their masters as ordinary dogs. A domesticated stock might thus have readily been produced. If this one domestic dog had originated in the taming by man of an indigenous wild animal, then the general problem of the original taming of domestic dogs would take this form: "Can we find wild stock so similar to the existing dog that there is no improbability in concluding them to be the same animals?" He thought we could. We might trace dog-like animals farther and farther west until, in northern Africa, we had a whole series of kinds of such animals usually known as jackals, presenting every conceivable gradation between the characteristic of the dog and the characteristic of the jackal. He believed these wild stocks were the source whence, in each region of the world, the savages who originally began to tame dogs had derived their stock. This was confirmed by the latest archæological evidence. The monuments of ancient Egypt had preserved a great variety of dogs, but it was an interesting fact that the oldest monuments contained the smallest number of varieties, and in the third and fourth dynasties there were only two well-marked forms of dogs—one a small, cur-like animal, resembling the one that now haunted the streets of Cairo, and the other of a form more like that of the greyhound. The cur was, no doubt, a tame species of the wild jackal, which was still to be found in the same country; and, with respect to the greyhound, there was in Abyssinia a very long-headed dog, which was very much of the same form as the greyhound, and which it could hardly be questioned was the source from which it sprang. Assuming that the origin of the dogs could be traced to these sources, the more modified forms of the domestic animal were simply the result of the selected breeding which had given rise to similar modifications in dogs as it had done in the case of pigeons. Referring to the origin of dogs in general, Professor Huxley noticed the discovery of a fox-like animal of the Pleiocene period, which was found near the Lake of Constance. An animal, the cynodictus, lived in the upper Eocene period whose dentition was substantially that of the dog, and which appeared to bridge over the wide interval that separated the bears and animals of that order from dog-like forms. Beyond that period there was no distinct trace of dog-like animals. By the application of ordinary common-sense reasoning, which was verified every day by experience, they were driven to the conclusion that they could only attribute the origin of these animals to causes which operated in the existing course of nature. This left them to the simple alternative of the doctrine of evolution. He believed that small differences of form—slight modifications of one main plan—were amply sufficient to give rise to the existing dog-like animals, and that these modifications had actually taken place, starting from the cynodictus.

Efficiency of Lightning-Conductors.—Direct evidence as to the efficiency of lightning-conductors is afforded in a government report from Schleswig-Holstein, which is referred to in a recent work on the subject by Mr. Richard Anderson. Thunderstorms are said to be more numerous in Schleswig-Holstein than in any other part of central or northern Europe, and the danger from lightning is correspondingly increased. The attention of the government insurance-office was called to the fact that, in four out of 552 cases of claims on account of damage from lightning arising in eight years, conductors of approved design had been in use, and an expert, Dr. Holtz, of Greifswald, was appointed to inquire into the causes of failure. He found that, in every case where a building provided with a conductor had been struck by lightning, the conductor was not in an efficient state. Sometimes the point of the rod was needlessly ornamented with gilding, while the underground connection with the earth, the very element of safety, was neglected. In the absence of a proper ground connection, the lightning-rod, instead of being a protection, may prove the means of attracting the discharge into the building. A measure for the periodical testing of conductors is suggested, for the detection of defective constructions, interruptions of conductivity by rusting or displacement, or of other faults that may arise from time to time.

Atmospheric Currents and Carbonic Acid.—M. Marié Davy, of the Observatory of Montsouris, France, has made a report of observations which he has taken for four years on the proportion of carbonic acid in the air as it is related to the grand atmospheric movements. The quantity of this gas is found to vary from twenty-two to thirty-six parts in one hundred thousand parts of air. During the earlier observations, extending to December, 1877, the proportion of carbonic acid was below the mean, and sometimes fell very low. In a second period, from December, 1877, to September, 1879, the proportion was considerably above the mean. A third period began in October, 1879, which was characterized like the first period by a relative weakness of proportion. The weakness became remarkable in December. The second period, in which the carbonic acid was superabundant, was characterized by moist weather with a predominance of the equatorial current over France, and embraced two years of short crops. The first period was characterized by an inferior extension of the equatorial current, by less wet weather and better crops. During all of the time of the observations, the proportion of carbonic acid showed no variation to correspond with the changes of the wind or the indications of the barometer, thermometer, and hygrometer. The fall of rain had no definite effect on the proportion. It thus appears that the proportion depends on the general predominance of the equatorial current, and not on the temporary changes of weather.

An Electrical Experiment of the Eighteenth Century.—The apparatus here represented is composed of a globe of sulphur which a young abbé causes to turn by means of a crank and wheel, while the woman excites electrical action by means of the friction of her hand on the ball. A young man suspended horizontally by cords of silk becomes electrically excited, and causes the spark to fly from the end of his finger by putting it near a stick which another experimenter extends toward him. Experiments of this kind were much in fashion about the middle of the last century. They assumed many variations, but the one here represented was repeated frequently. The contrast between this simple apparatus and the hundreds of machines from the most delicate to the most powerful, applicable to a wonderful variety of purposes possessed by the electricians of the present day, helps us to realize the amazing rapidity with which improvements are made, and justifies the liveliest hopes for the advancement of electric art in the future.



AN OLD ELECTRICAL EXPERIMENT.

Lessons from the Tongue of the Bee.—Professor A. J. Cook publishes, in the "American Bee Journal," some extremely interesting conclusions, which he has derived from the study of the tongue of the honey-bee. The accounts of the entomologists who have written upon the construction of this organ are conflicting and generally inaccurate. They do not agree as to its shape; some say that it is solid, others that it is tubular; some that the insects lap the liquids in which they feed, others that they take it by suction. By combining the studies that have been made by Mr. V. T. Chambers and Mr. J. D. Hyatt on the anatomy of the tongue of the bee with his own investigations, Professor Cook has been convinced that those who believe that the liquid is lapped up, that it is sucked through the tongue as a tube, and that it is drawn through a tube which is formed by the approximation of the ligula (or tongue), the palpi, and the maxillæ, are all right. The physiology of the tongue and the related organs adapts them to use in either of these methods; the bee has been detected in gathering nectar by all of them; and the presence of the fluid in passage has been demonstrated in the several organs the use of which is required by the different theories. The honey appears to be most abundantly secured by means of the tube formed by the closing up of the ligula, the palpi, and the maxilla. The ligula, or tongue, extends several hundredths of an inch farther than the labial palpi, and is itself provided with a rod and slit which may be made a tube, and a funnel for gathering nectar. This instrument appears to be the only one which is available for use in gathering honey from small tubular flowers; and the examination of its construction explains why bees are so much longer in gathering from some flowers than from others, as those in which the combined tube is available. It is also probable that bees lap honey. The measurements of the tongues of bees show a uniformity in the length of those of bees from the same colony or apiary, but considerable difference in those of different breeds. In the same colony, tongue after tongue would show a variation of less than 0·25 of an inch from the base of the mentum to the tip of the ligula. The average length of the American black bee's tongue is about ·24 of an inch; that of the Italian bee is about ·02 of an inch longer. The longest tongues were found in some Cyprian bees. The difference in the length of the tongue is accompanied by a corresponding difference in the capacity of the bees for gathering honey. Honey in a vessel covered with fine gauze was placed before some Italian bees till they ceased to eat because they could no longer reach it. It was then placed before the black bees, but they could not reach it. A similar dish was given to the black bees first, and, after they ceased eating, the Italians continued to sip. Many trials gave similar results. This shows how the Italians can gather honey from flowers which fail to attract the black bees because the nectar is beyond their reach. It thus seems probable that the law of natural selection, which raised the Italian bees to their position of superiority, also gave them their longer tongues. Shut up in a narrow basin among the mountains, with only a limited range for food, competition must have been excessive among them, and the variations which gave any of them advantages over the others would come into the fullest play. Similar conditions may have determined the character of the Cyprian bees and other superior varieties of Europe.

The Violin: its Construction and Perfection.—In a lecture, which he recently delivered at the Royal Institution in London, on the construction, the history, and the sound of the violin, Mr. Haweis called attention to the variety in shape and style of instruments of the viol tribe, ancient and modern, as showing the inexhaustible fascination they possessed over the human mind. The wood was selected by the best makers of the old violins with extreme care. At Brescia, they used pear, lemon, and ash; at Cremona, maple, sycamore, "and, of course, pine. . . . The wood came into the markets of Mantua, Brescia, Cremona, Venice, Milan, from the Swiss southern Tyrol, unlimited in supply, often mighty timbers of great age—plentiful then, scarcer now. The makers had their pick; they tested it for intensity and quality. Cut strips of wood and strike them: you will see how they will vary in musical sound. When a good acoustic beam was found, the maker kept it for his best work. In Joseph Guarnerius and Stradivarius the same pine-tree crops up at intervals of years. A good maker will patch and join and inlay, to retain every particle of tried timber. Old wood is oddly vocal. As I sat in my room, surrounded by these instruments, I could not cough or move without ghostly voices answering me from the sixteenth, seventeenth, and eighteenth centuries; and even the old-seasoned backs and bellies of unstrung violins are full of echoes." Taking a violin and tearing it open, the lecturer continued: "The violin is made of fifty-eight or seventy pieces. It is a miracle of construction. It is as light as a feather and as strong as a horse. Wood about as thick as a half-crown, by exquisite adjustment, resists for centuries a pressure of several hundred-weight. The belly of soft deal, the back of hard sycamore, are united by six ribs of sycamore, supported by twelve blocks with linings. The sound-bar, running obliquely under the left foot of the bridge, is the nervous system of the violin; the sound-post, supporting the bridge, is the soul; through it pass all the heart-throbs or vibrations generated between the back and the belly; on its position depends mellowness, tightness, or intensity of sound. The prodigious strain of the strings is resisted first by the arch of the belly, then by the ribs, strengthened with the upright blocks, the pressure among which is evenly distributed by the linings which unite them, and, lastly, by the supporting sound-bar and sound-post and back." The secret of the ancient varnish, on which some of the qualities of the instrument probably depended, is still only partly revealed. Mr. Haweis believes, with Charles Reade, that it was an heterogeneous varnish, first of oil with gum in solution, then of color evaporated in spirit. Dod, as late as 1830, had the recipe for something very like the Cremona varnish; and, lately, Mr. Perkins has analyzed the varnish of Joseph Guarnerius and found amber in it, and has himself produced varnish of an extraordinary quality. The supreme interest of the violin lies in its simplicity, beauty, strength, subtilty, and indestructibility, and, above all, in its perfection as a musical instrument. It combines accent with modification of sustained tone. The organ has sustained tone without accent, the piano accent without sustained tone, the violin accent and sustained tone modified at will. Within its limits it is scientifically perfect; it has all the sensibility, and more than the compass, execution, and variety, of the human voice. It is not an invention, it is a growth; it has come together, it is the "survival of the fittest." Its rough elements were selected from a variety of instruments which preceded it. Before the end of the fourteenth century viols were made in great profusion of every style and shape, but the rise of the true violin tribe begins with the rise of modern music. When the true octave and the perfect cadena had been discovered, and the human voice was found to fall naturally into soprano, contralto, tenor, and bass, viol instruments, adapted to these four divisions, were gradually separated from the confusion of instruments and brought to a perfection of adaptability.

A New Anæsthetic.—Bromide of ethyl is recommended by Dr. R. J. Levis, of the Pennsylvania and Jefferson College Hospitals, Philadelphia, as an anæsthetic preferable, in most respects, to ether and chloroform. It acts rapidly, and the patient recovers quickly from its effects. As far as observed by Dr. Levis, after several months of experience in using it, it does not influence the circulation except sometimes to produce a slight increase in the rapidity of the heart's action, and in arterial pressure. Respiration is but little affected by it beyond its producing the ordinary characteristics of all anæsthetic sleep; in this respect, its action seems more to resemble that of ether than that of chloroform. Nausea and vomiting occur less frequently with it than with ether or chloroform. It vaporizes readily, and seems to be entirely eliminated through the lungs, having, in this respect, a decided advantage over chloroform, which is not entirely removed from the system. Its vapor produces no irritation in the respiratory passages. General excitement and the tendency to struggle occur far less frequently when it is used than in the early stages of the anæsthesia of ether, and, apparently, even than in that of chloroform. Complete anæsthesia is accomplished, it is estimated, in about one third less time than is the case with chloroform, and recovery from the effect is even comparatively more rapid, the time required for recovery generally not exceeding two minutes after the inhalation has ceased. The recovery is so complete that the patient is often able to stand and to walk immediately after awakening. Insensibility is usually produced in from two to three minutes. The longest period that has been required in Dr. Levis's practice was four minutes, the shortest one minute. The completion of the effect is clearly shown by the dilatation of the pupils of the eyes, which resume their normal condition when the sentient state returns. The vapor of this substance is not inflammable, so that it is free from the danger which attends the use of ether at night when lights are around. The ordinary essentials of the proper and safe production of anæsthesia must not, however, be dispensed with in the use of the new agent, for its safety is only comparative, and is not yet proved to be absolute. Dr. Levis, who acknowledges his indebtedness to Dr. Lawrence Turnbull, of Philadelphia, for the suggestion of this agent, now uses the bromide of ethyl, to the exclusion of other anæsthetics.

Slave-making Ants.—It may be edifying to such persons as take pride in physical prowess to know that on the battle-field ants distinguish themselves quite as signally as do human beings. Mrs. Mary Treat, in the "American Naturalist," thus describes a contest which she witnessed between slave-making ants and black ants: The former were the aggressors, and victorious. The two colonies were one hundred and twenty feet apart. An idea of the numbers constituting the ranks of the slave-makers may be gathered from the fact that on the war-path, one hundred and twenty feet in length and a foot wide, they "were not thinly scattered, but a vast moving phalanx." The blacks, a grand army on their own territory, would not flee. The battle-field was about twenty-five feet in circumference. A roar announcing the beginning of hostilities lasted for five minutes, "whereas the battle lasted four or five hours before the reds gained possession of the vast nurseries of the blacks," and it took two days to carry the pupæ and prisoners to their own dominions.

Epidemics.—Sir Joseph Fayrer, in his address delivered before the Epidemiological Society of London, on the subject of epidemics, gives some interesting facts regarding typhoid fever and cholera in India. It is well known that typhoid fever is a prolific cause of mortality among European soldiers there, and questions of great practical importance arise in regard to the age, time, and seasons for sending men to the army in India. It appears from the statistics that this disease tells most severely upon the young men during their first year of service; and Dr. Fayrer raises the question as to whether this fever, so prevalent in India, is identical with the disease which might be contracted in London, New York, or Dublin, from water-closet, drain, sewer, or well. He is of the opinion that these fevers are often the same, but that more frequently they are not, and that in hot, malarious countries climatic causes give rise to fevers identical with the others, except that they can not be traced to filth or other specific cause. But, while recognizing that but little is known of the nature of epidemics of this class, he asserts that the past twenty years show great progress in ability to successfully cope with them. He says, "Science that has enabled us to reduce the death-rate among our troops from 17·9 to 8·56 per 1,000 in Europe, and from 69 to 17·62 per 1,000 in India, speaks for itself, and, were there no other results, this alone is a triumph such as has not been achieved by other departments of knowledge." As a result of better sanitary conditions among European troops the following alteration in the death-rate is shown: from 1861 to 1865, 9·02 per 1,000; 1865 to 1870, 6·98; 1870 to 1875, 3·23; 1875 to 1876, 2·3; 1876 to 1877, ·84. In allusion to the history and treatment of cholera the doctor says: "All serves to show that it is the same now as formerly, and that, though we have gained much knowledge of its natural history of late years, yet we are as ignorant as our predecessors of its real nature. We have, thanks to sanitary measures, disarmed it of some of its terrors, and have diminished the mortality it caused; but as to treatment we have gained but little, though the empiricism of to-day is more scientific than it was in former days. We do not now burn our patients on the soles of the feet, tie ligatures round their limbs, or have recourse to other senseless barbarities; for we find that simpler and more rational methods are of greater avail, more or less according to the period of the epidemic attack, and the promptitude with which the remedies are applied. But we have learned that local causes have a potent influence, and that cleanliness, good air, *pure water*, and free ventilation, are all powerful opponents of cholera."

Danger of the Hypodermic Use of Morphia.—The danger of using morphia in hypodermic injections has been again forced into notice by the recent death of the Italian Consul at Bombay, India. His physician had prescribed two "grana" of morphia as a remedy for a pain in his leg from which he was suffering. The chemist mistook the word "grana" for "grammes" and gave fifteen times as much morphia as was intended. The mistake was discovered at once and remedies were applied, but the patient sank rapidly and died the same evening. The peculiar risks of the hypodermic use of morphia arise from the facts that an overdose once administered can not be recalled, and that no means exist of ascertaining how large a dose the patient can bear. An excessive quantity of morphia given by the mouth may be removed if the accident is discovered immediately, but the only resource in case of excessive injection lies in antidotes, the operation of which is very uncertain. According to the collection of facts on this subject which has been published by Dr. Kane, of this city, the smallest single dose which has appeared to have alone been the cause of death was a quarter of a grain. In a case in which death apparently resulted from the administration of a twelfth of a grain by the skin, a quarter of a grain had previously been given by the mouth. In three of the cases cited by Dr. Kane, including one in which a quarter of a grain caused death, the patients were suffering from delirium tremens; in the majority of the cases the fatal effect was due to the repetition of the hypodermic injection, or to its employment after a fair dose of opium had been given by the mouth. It is impossible to predict, or to estimate with any approach to safety, what the effect of an injection will be. Tolerance of opium by the mouth does not prove that it will be tolerated equally well by the skin; and tolerance of morphia by hypodermic injection at one time is no ground for inferring that at another time the same dose would be equally well borne. The use of morphia is peculiarly dangerous in certain morbid states, foremost among which is alcoholism. The existence of chronic Bright's disease increases the danger, as does also the existence of disease of the heart or lungs, interfering with circulation and respiration. The fact also seems to be established that the existence of severe pain does not render large doses better borne. Atropine is capable to some extent of counteracting the influence of morphia, but can not be relied upon alone. It needs to be supplemented by other remedies, and is assisted by the hypodermic injection of strychnia. It also will kill, and should not be used in a larger proportion than one twenty-fifth of a grain of atropine to every grain of morphia. Strychnia should not be used in a larger total quantity than one twentieth of a grain, and a much smaller dose should be first administered. Artificial respiration, electricity, and coffee or caffeine, remedies in common use, may also be necessary in addition. Whenever there is reason to think that the injection has been directly into a vein, the circulation in the limb should be arrested by a ligature above the place of injection; and the "Lancet" suggests that it is possible, when the fact of an overdose is at once discovered, that something may be done by local treatment to arrest absorption. The whole of the morphia can hardly be taken up instantaneously, and it is probable that, if a ligature were at once placed on the limb, an incision made through the skin at the seat of the injection, and the part freely washed, or even freely cauterized, the amount of morphia absorbed might be reduced to so small a degree that it would be possible to antagonize it, and thus save the patient's life.

Sanitary Perils at Watering-Places.— The "Lancet" has uttered a warning against the sanitary dangers to which populous health resorts are liable, which receives support from several incidents that have happened within a few years past. It is incumbent upon every one who goes to the seaside, to take care that he does not leave a comparatively healthy home to seek recreation in a place which may be a nursery of disease. Watering-places are peculiarly liable to have two kinds of perils: to the danger that infection may be brought to them by visitors, and to the risks that may arise from the insufficiency of their sanitary arrangements to meet the demands that are made upon them by the accession of large crowds. It has sometimes happened that, as soon as a child has become convalescent from an infectious disease, it has been hurried off to the seaside, and been received at lodgings without question. The sanitary precautions now carried out at many places make this a matter of more difficulty than formerly, but the danger is still hardly diminished that arises from sending off the unaffected members of an affected family to the seaside as soon as contagious disease breaks out. The "Lancet" tells of a case as having come under its own notice, in which, when a child was taken ill with a sore-throat of a suspicious character, another child in the family was sent to the seaside, was taken ill with diphtheria on the day after his arrival, and communicated the disease to other children with whom he had played. When disease breaks out in the height of the season, the fact is apt to be concealed as long as possible, and unknowing visitors continue to go down as into a trap. "Not long ago," again says the "Lancet," "family after family went down to one of our [English] largest seaside towns, to be infected with scarlet fever, the existence of which at the place was carefully concealed." The dangers arising from imperfect sanitary arrangements at these resorts and in the lodging-houses have been much discussed of late, but the agitation ought to be kept up without intermission till they are all remedied. The question of drainage, which is a difficult one anywhere, is no less difficult at seaside resorts than at other places. The most natural measure is to carry the sewage to the nearest and most convenient spot at which it can pass into the sea, and this is often the place where visitors and loungers will be most exposed to its emanations. The case is still worse on lakes, for there the slowly moving water becomes charged with sewage; and cases of illness have been known to arise from boating in the neighborhood of the discharge-pipes. Many physicians have had experience with diseases arising from filth that have been contracted at the seaside, and cases of typhoid fever originating in such places have been noticed in England as well as in the United States. That sickness is not more general is doubtless due to the fact that visitors spend so much time in the open air. If they lived there as they do at home, they would, perhaps, find many of these places the reverse of "health resorts."

Rhythmic and Colored Lights for Lighthouses.—Sir William Thomson urges a threefold reform in the British lighthouse system, viz.: "A greater quickening of nearly all revolving lights; the application of a group of dot-dash eclipses to every fixed light; and the abolition of color as a distinction of lighthouse-lights, except for showing dangers and channels and ports by red and white and green sectors." He observes that, in revolving lights of which the period is ten seconds or less and the time of extinction seven seconds or less, the place of the light is not practically lost in the short intervals of darkness, the eye sweeping deliberately along the horizon to "pick up the light, passes over less than the breadth of its own field of view in the period of the light, and thus picks it up almost as surely and quickly as if it were a fixed light. Compass-bearings may also be taken with these quick-revolving lights almost as easily and accurately as if the light were continuous. The distinction by color alone ought to be prohibited for all lighthouse-lights, on account of its liability to confusion with ships' and steamers' side-lights. In place of color, Sir William would distinguish every fixed light by a rapid group of two or three dot-dash eclipses, the shorter, or dot, of about half a second duration, and the dash three times as long as the dot, with intervals of light of about half a second between the eclipses of the group, and of five or six seconds between the groups, so that in no case should the period be more than ten or twelve seconds. The Holywood Bank Light, Belfast Lough, until 1874 was inclosed in a red-glass lantern, was only visible for five miles, and was constantly liable to be taken for a sailing vessel's port-side light. In 1874 the red glass was removed, and the light was marked by a dot, dot, dash (. . —, or letter U of the Morse flashing alphabet), repeated every ten or twelve seconds, and has been so ever since. It is now recognized with certainty as soon as seen in ordinary weather from the mouth of the Lough, ten miles off, and has proved most serviceable as a leading light for ships bound for Belfast or entering the Lough. Sir William Thomson's objection to colored lights is corroborated by Mr. J. P. Thompson, who relates, in a letter published in "Nature," how he narrowly escaped shipwreck off the Cornish coast by inability to perceive the red flashes of the "Wolf" light, which seemed to have been neutralized by the fog, or from the daze caused by the phosphorescence of the sea.

A Singular Root-Growth.—A correspondent of "Die Natur" describes a singular form of growth of fibrous roots, which he and his associates observed in opening one of the ancient-burial places, called cromlechs, at a town in the province of Posen, Prussia. Along with other objects usually found in such burial-places, they noticed several urns, filled with ashes, calcined bones, and sand, and all closed with a cover shaped like a basin, and fitting tightly over the rim of the urn. They took off the covers and emptied the vessels, when they were astonished to find that the surface of the sand in one of them was apparently covered with a deep-black peruke, ornamented with pearls of about the size of a pea. A more careful examination showed them that this curiously discovered "head-dress" was composed of the fibrous roots of the horse-tail rush, which grew abundantly on the top of the hill in which the graves had been made. The roots of the plant having penetrated the soil to the depth of three feet and a half, had made their way through the narrow crevices between the stones of the grave, had found the urns, had then pushed up perpendicularly through the minute space between the rim of the cover and the neck of the urn, and had arranged themselves within the urn into a regular network. After the formation had been dried, the course which the principal root had taken could be traced. The fibrous roots had branched out from it, and covered the whole surface of the sand in such a manner as to deceive the observers for a time with the resemblance to a beautiful head-dress. The knots, which were taken for pearls, were irregularly distributed, and were manifestly thicker in places in the principal root. The formation affords an interesting illustration of the faculty which the roots of plants possess of seeking for and reaching the most suitable nourishment. The operation in the present instance involved a reversal of the common direction of the growth of roots, and that which resembled an effort to reach hidden food. The case furnishes a curious parallel to the one which was described in this country a few years ago, in which the root of an apple-tree, which grew over the grave of Roger Williams, was found to have taken the place and shape of the body buried below.

Artesian Wells on our Western Plains.—A proposition to make an appropriation of fifty thousand dollars for the purpose of sinking experimental artesian wells in the Western Plains, has been advocated in Congress, and has been mentioned favorably in the press. It is urged in behalf of the scheme that of about nine hundred million acres of arid lands in Arizona, Dakota, Idaho, Montana, New Mexico, Utah, Wyoming, Colorado, and Nevada, which must remain practically a desert unless some method is found to supply them with water, about five hundred million acres of plain and valley lands would be susceptible of profitable cultivation if they could be watered. Of this, not more than three per cent. can be irrigated by the use of existing streams and rivers. It has been demonstrated, wherever settlement has been made and irrigation applied, that the lands when watered are as good as any; and the operations of the French in Algeria, which are still continued, give an encouraging promise of what can be accomplished with artesian wells.

African Fetich-Worship and Witchcraft.—Dr. Buchholz, a German entomologist, in his account of his wanderings in west Africa, notices many of the peculiar customs of the negroes of Upper Guinea, particularly those relating to fetich-worship and witchcraft. While among the Akkra tribes of the Gold Coast, he found that fetiches, generally clay dolls representing a man and a woman, had been laid at the foot of the termite-hills which he was interested in examining, with offerings around them. The fetich-processions are celebrated with considerable pomp, in which the fetich-drum, a stick provided with rings on which a little hollow ball, a gourd-shell, is rapidly struck, plays an important part. At the village of Abreri, farther inland, the ceremonies were held in a large, open place, at one end of which silvered images of the gods, rude figures representing a bird, a turtle, an ear of corn, and a figure holding different vessels, were set up in an orderly manner on a pillar, while the priest performed his ritual at the other end. The music, of drums, bells, and other instruments, including a drum of bronze, was accompanied by the multitude with a rhythmical hand-clapping. At the feast of the new moon, in addition to the music and the singing, each participant had a white streak drawn over his face, and the master of ceremonies, swinging a peculiar brush and gesticulating frantically, had his face painted all over white. The Bakhniri believe, when any one dies or is sick, that he has been bewitched; or if death is caused by a snake, or a crocodile, or a leopard, that the animal has been bewitched to cause it. The person accused of witchcraft is compelled to drink a decoction of a poisonous wood called sassha-wood; if he vomits up the drink, he is considered not guilty and let go; otherwise, he is killed if he does not die of the poison. They have a great fear of white people and all that comes from them, and especially regard paper that has been written upon as a fetich and the place or the thing on which it falls as *taboo*. When Dr. Buchholz on one occasion dressed the wounds of a sick person, he let a little piece of paper fall out of his pocket without noticing it. When he next went to visit the sick man, he found that his patient had been quarantined because the house was considered bewitched, and the piece of paper was ceremoniously handed back to him. One day, when a woman was to be buried, the negroes sent a messenger to him with a special request that he would not leave any pieces of paper anywhere that he went, because, if he did, they would have to keep away from those roads and places. A son of old King William, of Bimbia, having died after a long sickness, an innocent man was accused of having caused his death by witchcraft. He was taken out and hung; immediately the whole population, men, women, and children, ran to the shore, stripped off the little they had on, and went into the water to wash off whatever enchantment might be on them. One of the festivals among the Deialla negroes was diversified by an exhibition of single combat. The champion who achieved the most brilliant victory was hailed with great applause, and his mother sung and danced to his honor; but one of the defeated ones went up to his mother and reproached her because she had not given birth to a stronger son.

A Remarkable Coal-Mine Explosion.—M. A. Delesse gives in "La Nature" an account of an explosion of carbonic acid which took place in a coal-mine at Rochebelle, France, on the 28th of July, 1879. Two workmen, who were at the bottom of a shaft about three hundred and seventy-five yards deep, heard a sudden detonation, which was followed in about a minute by another louder one. Their lamps were instantly put out; they felt a faintness, and were barely able to escape to the hoist-car and be drawn out. Three other miners, who were working in a gallery ninety yards higher, were suffocated. The scene of the disaster was afterward examined, and it was decided that the explosions could not have proceeded from carburetted hydrogen, for they were not accompanied by flames; thin partitions in the shaft and upper galleries were not broken; the bodies and clothes of the dead men showed no signs of having been burned; and powder which lay in the gallery and in cartridges had not taken fire. No signs of carburetted hydrogen had ever been observed about the mine, but carbonic acid had always been present, sometimes in such quantities as to compel the men to cease work, and a ventilating apparatus had been put up to discharge it. The explosion was found to have taken place in front of the excavations in one of the upper galleries (two hundred and sixty-six yards below the surface), which was obstructed for a considerable distance by the broken coal. Small particles and dust were thrown out to a much greater distance, and the man who was working in front had been thrown back and buried under the fragments. About seventy-six tons of coal appear to have been displaced by the explosion. Carbonic acid continued to escape from the coal after the accident, and even the pieces that had been thrown into the gallery gave it out when they were disturbed. No satisfactory explanation has been offered of the manner in which the gas could have accumulated, and have gained so high a pressure as to cause a detonating explosion. The gas, it is suggested, may have been formed by the action of the sulphuric acid which escapes from a vein of rapidly oxidizing iron pyrites in the neighborhood upon an adjoining bed of limestone, but this leaves the question of a violent explosion still unsolved.

A Systematic Investigation of Earthquakes.—The Swiss Natural History Society has appointed a special commission of seven members for the systematic observation of earthquakes. Recognizing that a large number of observations at as many places as possible is necessary for the sufficient investigation of every earthquake, the commission has taken measures to enlist those persons generally in its own country who are interested in investigations of this kind in coöperation with its work, and is perfecting a special organization for the collection of observations with the aid of such assistants. A special field is assigned to each member of the commission, and he is expected to put himself in communication with persons who may be disposed and competent to aid him in different parts of his district. A tract for distribution has been published under the direction of the commission, which contains a summary of the most recent facts that have been ascertained about earthquakes, and points out the directions in which an increase of knowledge on the subject can be promoted. A number of stations, selected by the commission, are provided with instruments for special observations. The observers are furnished with a schedule of questions respecting the different phases of the earthquakes they may witness, which they are expected to answer as fully as they are able to do. They are also requested to represent the phases of the shock graphically on a chart, where it is possible, to assist in comprehending and reviewing the character of the phenomena. The collected accounts of observations are arranged and preserved in an archive of earthquakes. As the questions concern a subject of general interest, and are useful aids to investigation everywhere, we repeat them entire. They are seventeen in number, as follows: 1. On what day was the earthquake noticed? 2. At what hour? 3. How did your clock agree on the day, or, better, on the hour, of the earthquake, with the nearest telegraph clock? 4. Endeavor to furnish an exact description of the place of observation, the canton, town, situation, whether in the open or among buildings, in what story of the house; state in what position and what occupation the observer was when the shock was perceived? 5. On what kind of soil does the place of observation stand? Whether the surface be of rock, soil, or peat; depth of the ground to bed-rock, etc.? 6. How many shocks were felt, and during what interval of time? 7. In what direction was the motion? Did it come from below, was it short and in a direction from side to side, or broad, surging in the form of waves, or only a trembling? In case there were more than one shock, was there a difference in the character of the different shocks? With what could the motion be compared, and how did it affect the observer? 8. In what direction was the trembling of the earth felt? 9. How long did the shocks and the subsequent trembling seem to last? 10. What effects did the shaking produce? 11. How might this earthquake be distinguished from others which have previously been noticed by the same observers? 12. Was any noise heard, and, if so, what kind of a noise was it—like thunder, a clinking, a rattling, a clap, or a continuous noise, etc.? 13. Did the noise precede the shaking or follow it, and how long did it last in comparison with the duration of the shocks and of the intervals between them? 14. What particular minor phenomena were observed? Were there, for instance, anything peculiar in the behavior of animals; any drying up, or troubling, or breaking out again of springs; any peculiar rustling in the woods, any gusts of wind simultaneous with the shocks, or abnormal features of the weather? 15. What was noticed with regard to the lakes? 16. Were lighter shocks felt before or after the main shocks, and at what time? 17. Can you mention any other observations made by your acquaintances or in your neighborhood, or can you give the addresses of persons who are able to answer all of these questions, or a part of them?

Precocity a Sign of Inferiority.—M. G. Delaunay, in a communication to the French Société de Biologie, has advanced the opinion that precocity is a sign of biological inferiority. In support of his position he adduces the fact that the lower species develop more rapidly, and are at the same time more precocious, than those higher in the scale. Man is the longest of all in arriving at maturity; and the inferior races of men are more precocious than the superior, as is seen in the children of the Esquimaux, negroes, Cochin-Chinese, Japanese, Arabs, etc., who are, up to a certain age, more vigorous and more intellectual than small Europeans. Precociousness becomes less and less in proportion to the advance made by any race in civilization—a fact which is illustrated by the lowering of the standard for recruits, which has been made necessary in France twice during the present century, by the decreasing rapidity of growth of the youth of the country. Women are more precocious than men, and in all domestic animals the female is formed sooner than the male. From eight to twelve years of age, a girl gains one pound a year on a boy, and in mixed schools girls obtain the first places up to the age of twelve. The inferior tissues and organs develop before the higher ones, and the brain is the slowest of all organs to develop. M. Delaunay concludes his paper by stating that the precocity of organs and organisms is in an inverse ratio to the extent of their evolution.

NOTES.

According to Dr. Abercrombie, a gentleman who had been a soldier dreamed that he heard a signal-gun, saw the proceedings for displaying the signals, heard the bustle of the streets, the assembling of troops, etc. Just then he was roused by his wife, who had dreamed precisely the same dream with this addition, that she saw the enemy land and a friend of her husband's killed; and she awoke in a fright. This occurred at Edinburgh, at the time when a French invasion was feared, and it had been decided to fire a signal-gun at the first approach of the foe. The dream was caused, it appears, by the fall of a pair of tongs in the room above; and the excited state of the public mind was quite sufficient to account for both dreams turning on the same subject.

The French forestry department, according to the "Polybiblion," have arrived at the conclusion that forests directly increase the supply of water in their neighborhood. From observations at Senlis and Nancy, they have decided that it rains more abundantly in wooded tracts, and that, while the leaves and branches give back the water quickly to the air, they prevent rapid evaporation from the ground, and are thus favorable to the formation of springs.

Dr. Ludwig Moser, Professor of Physics in the University of Königsberg, died in the latter part of February, aged seventy-five years. "Long," says "Nature," "before photography had become a practical art, Dr. Moser had acquired considerable reputation by his systematic and successful experiments in this department."

Specimens of the volcanic ashes which rained down upon Dominica have been analyzed by M. L. Best. The lye was found to be rich in chloride of potassium. The predominant constituents of the solid part were silicates (feldspar and pyroxene), and pyrites in perfectly defined cubic crystals.

Another severe outbreak of scarlet fever, which occurred near Manchester, England, last summer, and in which thirty-five persons belonging to eighteen different families were attacked, twenty-five within thirty-six hours, has been traced by the health authorities to the distribution of the infection through the milk-supply.

Herr Baumgartner, a German, has invented a balloon for navigation, having three cars attached, each with ten or twelve rings, to be set in motion by a crank. He recently attempted an ascension with his machine at Leipsic. When the balloon was rising very slowly and skimming the house-tops his two assistants, in their alarm, jumped out. Upon this the balloon shot up to a great height, then burst and fell. The inventor was not seriously hurt, and is resolved to make a second experiment.

Rev. James Clifton Ward, F. G. S., from 1865 to 1878 an active working member of the English Geological Survey, and a popular writer on geological subjects, died April 13th, at the early age of thirty-seven.

"Nature" quotes from the "Bombay Gazette" an account of a remarkable thunderstorm that occurred at Dharwar, in March last, during which "hailstones fell measuring no less than nine or ten inches in circumference." The thunder and lightning were terrific, and, after the fall of hail, there was a heavy down-pour of rain. We thought the hailstones mentioned above were the largest ever heard of, but it turns out, as usual, that the West is ahead in hailstones as well as meteors and other celestial commodities. The "Bulletin" of the Iowa Weather Service, for April, 1880, received since the above was written, tells of thunderstorms during the month, in that State, where hailstones fell measuring *twelve* inches in circumference.

The death is announced of Karl von Seebach, the distinguished Professor of Geology at Gottingen. Although still a young man at the time of his death, he had done a large amount of valuable work, especially in the investigation of volcanic phenomena.

A scientific association has been formed in Algeria on the plan of the British and

American Associations, and has already enrolled one hundred and fifty members. Its first bulletin contains a paper on the fevers of Algeria, which affords the most satisfactory evidence that a great improvement has been made in the sanitary condition of the country, by the operation of the hygienic measures which have been carried out by the civil and military authorities, consisting of the clearing of the ground, drainage, plantations of trees, etc. During the thirty years from 1845 to 1875 the death-rate of the European population fell from 50 to 38 per thousand inhabitants. The diminution of mortality is shown in a still more striking degree in the army, where it fell from 77·8 per thousand men between 1837 and 1846, to 12·3 per thousand in 1876, and 12·5 in 1877. These proportions are very near to the rate of mortality in the interior of France itself, which was equivalent to ten deaths among a thousand effective men during 1876.

Professor Boyd Dawkins, F. R. S., of Owens College, Manchester, has engaged to deliver a course of lectures on "Primitive Man," at the Lowell Institute, Boston, in October and November of this year.

M. Raoul Pictet recently delivered a lecture in Paris on "Cold and its Applications to Science and Industry," in the course of which he struck a medal with fifteen kilogrammes (or thirty-three pounds) of solidified mercury.

The case mentioned by Dr. Coues of a breed of one-toed hogs has a parallel in that of a one-toed deer, the feet of which were recently presented to the California Academy of Sciences. The third toe is described as the only one used for progression, though there were different degrees of development in the respective feet.

Mr. Thomas Ball, F. R. S., F. L. S., died at Selborne, Hampshire, England, on March 13th, aged eighty-seven. He was for a long time Professor of Zoölogy at King's College, and the writer of several works on natural history. The last eighteen years of his life were spent at the breakers at Selborne, the former home of Gilbert White the naturalist, which he purchased, and made the repository of numerous memorials of White, that, with the house and grounds, were always kept open to visitors.

A commissioner of the London "Morning Post," who has been examining the condition of the Riviera between Cannes and San Reno, reports the existence of an interesting state of things in that famous health resort. There are no sewers; cesspools are universal, and so placed as to be sources of danger to the inmates of the houses; public water-supply there is none, and the rain-water drains, which are also conduits for the cesspools, have slight gradients, are never flushed, and are generally the sources of foul emanations; and, to cap all, the beaches and promenades near the sea are soaked with sewage which also chokes the almost tideless bays.

Arthur Jules Morin, born in Paris, October 17, 1795, died in that city on the 7th of February last, in his eighty-fifth year. Besides a brilliant military career, in which he reached the position of artillery general of division, he was distinguished as an investigator, chiefly in the field of mechanics. He also possessed executive abilities of a high order, and held for thirty years the directorship of the Conservatoire des Arts et Métiers, which, under his administration, became the leading school for the artisan classes in Paris. He was president of the commission for the first Universal Exposition held in the French capital; in 1862 was elected President of the French Society of Civil Engineers, and has been a member of the French Academy of Sciences since 1843.

Mr. C. W. Siemens, pursuing his observations on the influence of the electric light on vegetation, finds that, by its use, the growth and ripening of fruit may be greatly hastened. At a recent meeting of the Royal Society of London, he exhibited two pots of strawberries which had been grown in the usual way until the fruit-buds appeared, when one was exposed to daylight during the day and the electric light at night, the other being left to the influence of ordinary daylight alone. The former, or the one exposed to continuous light, bore a bunch of large, red, fragrant berries, while on the other the berries were still green with the exception of one, that bore a slight red spot.

Dr. William Sharpey, M. D., F. R. S., the eminent physiologist, died in London, April 11th, at the age of seventy-eight. He graduated in medicine at twenty-one, practiced a short time, and then went to the Continent for the purpose of continuing his studies. Subsequently he returned to Edinburgh, and began to lecture on anatomy; and, five years later (1836) was appointed to the chair of Anatomy and Physiology of the University of London (now University College), which he occupied for thirty-eight years. During this period he became celebrated as a teacher and original investigator, and, though not a voluminous writer, his contributions have always held a high place in the literature of these departments of science. He was for some years Secretary of the Royal Society, and, from 1840 to 1863, Examiner in Anatomy and Physiology to the University of London.

FREDERICK WÖHLER.

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THE KEARNEY AGITATION IN CALIFORNIA.

By HENRY GEORGE.

ALTHOUGH something has been done toward the scientific treatment of history and of the larger facts of sociology, the conception of the reign of law amid human actions lags far behind the recognition of law in the material universe, and the disposition to ascribe social phenomena to special causes is yet almost as common as it is in the infancy of knowledge so to explain physical phenomena.

We no longer attribute an eclipse to a malevolent dragon; when a blight falls on our vines, or a murrain on our cattle, we set to work with microscope and chemical tests, instead of imputing it to the anger of a supernatural power; we have begun to trace the winds and foretell the weather, instead of seeing in their changes the designs of Providence or the work of witch or warlock. Yet as to social phenomena, infantile explanations similar to those we have thus discarded still largely suffice us. One has but to read our newspapers, to attend political meetings, or to listen to common talk, to see that very many people, who have in large measure risen to scientific conceptions of the linked sequence of the material universe, have not yet, in their views of social facts and movements, got past the idea of the little child who, if shown a picture of battle or siege, will insist on being told which are the good and which the bad men.

As the conductors of this magazine evidently realize the importance of popularizing in their applications to social questions the scientific spirit and scientific method, which in other departments have achieved such wonders, I propose in this paper to say something of a series of events in California that has attracted much attention. In an article such as this, I can, however, do little more than correct some misapprehensions and put the main facts in such relations that their bearing may be seen. Much that would conduce to complete intelligibility must, from the limit of space, be omitted.

What seems to be the general idea of these events is well suggested by one of Nast's cartoons—a hideous figure, girt with revolver and sword, broadly badged as "communist," brandishing in one hand the torch of anarchy, and in the other exhibiting a scroll on which is inscribed: "Mob Law. The New Constitution of California. Kearneyism. Other people's homes, savings, land, property, lives, capital, and honest labor, all common stock in the universal coöperative brotherhood." In the distance a group of workmen stand idle and cowering, while underneath is the device, "Constant Vigilance (Committee) is the price of liberty in San Francisco."

While such ideas are but exaggerated reflections of the utterances of San Francisco papers, they are wide of the truth. There has not been in San Francisco any outbreak of "foreign communism," nor yet has there been in the workingman's movement, or in its results, anything socialistic or agrarian. This movement has in reality been inspired by ordinary political aims, and what has been going on in California derives its real interest from its relation to general facts and its illustration of general tendencies.

While there has been much in these events to recall to the cool observer the saying of Carlyle, "There are twenty-eight millions of people in Great Britain, mostly fools," it is yet a mistake to regard California as a community widely differing from more Eastern States. I am, in fact, inclined rather to look upon California as a typical American State, and San Francisco as a typical American city. It would be difficult to name any State that in resources, climate, and industries comes nearer to representing the whole Union, while, as all the other States have contributed to her population in something like relative proportions, general American characteristics remain, as local peculiarities are in the attrition worn off. There is, of course, a greater mobility of society than in older communities, and this may give rise to a certain excitability and fickleness. But, everywhere, the mobility of population increases with the relative growth of cities and the increase of facilities of movement. And, in fact, the newness and plasticity of society in such a State as California permits general tendencies to show themselves more quickly than in older sections, just as in the younger and more flexible parts of the tree the direction of the wind is most easily seen.

Though yet comparatively a small city, San Francisco is in character more metropolitan than any other American city except New York, and is, to the territory and population of which she is the commercial, industrial, financial, and political center, even more of a center than is New York. San Francisco has no rival. For long distances her bay is spoken of as "the bay," and she is not merely the greatest city, but "the city."

And, though the European element is largely represented in San Francisco, it is, I am inclined to think, more thoroughly Americanized than in the Eastern cities. The reason I take to be, not merely that it is drawn from the more active and intelligent of the immigration that sets upon the Atlantic shore, and has generally only reached California after a longer or shorter sojourn in more Eastern States, but also that the American population having been drawn from all sections of the country, and from the early days the whole immigration having been rather of individuals than of colonies or families, the admixture has been more thorough, and, except as to the Chinese, that polarization which divides a mixed population into distinct communities has not so readily taken place.

Contrary, too, to the reputation which she seems to have got, San Francisco is really an orderly city. Although the police force has been doubled within the past two years, it still bears a smaller proportion to population than in other large American cities. Chinamen go about the streets with far more security than I imagine they will go about any Eastern city when they become proportionately as numerous; and, after all said of hoodlumism, there is little obtrusive rowdyism and few street fights—a fact which may in part result from the once universal practice of carrying arms.

Nor has communism or socialism (understanding by these terms the desire for fundamental social changes) made, up to this time, much progress in California, for the presence of the Chinese has largely engrossed the attention of the laboring classes, offering what has seemed to them a sufficient explanation of the fall of wages and difficulty of finding employment. Only the more thoughtful have heeded the fact that in other parts of the world where there are no Chinamen the condition of the laboring classes is even worse than in California. With the masses the obvious evils of Chinese competition have excluded all thought of anything else. And in this anti-Chinese feeling there is, of course, nothing that can properly be deemed socialistic or communistic. On the contrary, socialists and communists are more tolerant of the Chinese than any other class of those who feel or are threatened by their competition. For not only is there, at the bottom of what is called socialism and communism, the great idea of the equality and brotherhood of men, but they who look to changes in the fundamental institutions of society as the only means for improving the condition of the masses necessarily regard Chinese immigration as a minor evil, if in a proper social state it could be any evil at all. Nor is there in this anti-Chinese feeling anything essentially foreign. Those who talk about opposition to the Chinese being anti-American shut their eyes to a great many facts if they mean anything more than that it *ought* to be anti-American.

In short, I am unable to see, in the conditions from which this agitation sprang, anything really peculiar to California. I can not regard the anti-Chinese sentiment as really peculiar, because it must soon arise in the East should Chinese immigration continue; and because, in the connection in which we are considering it, its nature and effects do not materially differ from those which elsewhere are aroused by other causes. The main fact which underlies all this agitation is popular discontent; and, where there is popular discontent, if there is not one Jonah, another will be found. Thus, over and over again, popular discontent has fixed upon the Jews, and among ourselves there is a large class who make the "ignorant foreigner" the same sort of a scapegoat for all political demoralization and corruption.

There has been in California growing social and political discontent, but the main causes of this do not materially differ from those which elsewhere exist. Some of the factors of discontent may have attained greater development in California than in older sections, but I am inclined to think this is merely because in the newer States general tendencies are quicker seen. For instance, the concentration of the whole railroad system in the hands of one close corporation is remarkable in California, but there is clearly a general tendency to such concentration, which is year by year steadily uniting railroad management all over the country.

The "grand culture" of machine-worked fields, which calls for large gangs of men at certain seasons, setting them adrift when the crop is gathered, and which is so largely instrumental in filling San Francisco every winter with unemployed men, is certainly the form to which American agriculture generally tends, and is developing in the new Northwest even more rapidly than in California.

Nor yet am I sure that the characteristics of the press, to which San Franciscans largely attribute this agitation, are not characteristics to which the newspaper press generally tends. Certain it is that the development of the newspaper is in a direction which makes it less and less the exponent of ideas and advocate of principles, and more and more a machine for money-making.

There is, however, a peculiar local factor which I am persuaded has not been without importance. This is an intangible thing—a mere memory. But such intangible things are often most potent. Just as the memory of previous revolutions has disposed the discontented Parisian to think of barricades and the march to the Hôtel de Ville, so has the memory of the Vigilance Committee accustomed San Franciscans to think of extra-legal associations and methods as the last but sovereign resort. These ideas have been current among a different class from that which mans the Paris barricades. The Vigilance Committee of 1856, as most of the other California Vigilance Committees, was organized and led by the mercantile class, and in that class its memories have survived. The wild talk of the "sand-lot" about hanging official thieves and renegade representatives, and the armed organizations of workingmen, which have seemed at the East like the importations of foreign communism, are in large measure but reflections and exaggerations of ideas current in San Francisco counting-rooms and bank parlors. And it must be remembered, in estimating the influence of this idea, that the Vigilance Committee of 1856 was not merely successful in its immediate purposes, but gave birth to a political organization that for many years thereafter managed the local government and disposed of all its large prizes.

Yet, acting with and running through this, has been, I think, a wider and more generally diffused feeling—the disposition toward sharp repressive measures which is aroused among the wealthy classes by symptoms of dissatisfaction and aggression among the poor. That this feeling has of late years been growing throughout the Union many indications show.

Be all this as it may, the impulse that began these California agitations came from the East. For the genesis of Kearneyism, or rather for the shock that set in motion forces that social and political discontent had been generating, we must look to Pittsburgh and to the great railroad strikes of 1877.

In California, where a similar strike was about beginning—for the railroad company had given notice of a like reduction of wages—these strikes excited an interest that became intense when the telegraph told of the burning and fighting in Pittsburgh. The railroad magnates, becoming alarmed, rescinded their notice, but in the mean time a meeting to express sympathy with the Eastern strikers had been called for the sand-lot in front of the new City Hall. This meeting was called in response to a request of Eastern labor papers, but happened to fall amid the excitement caused by the Pittsburgh riot. The over-zealous authorities, catching, perhaps, the alarm that had induced the railroad managers to rescind their reduction, arrested men who were carrying placards advertising the meeting. In the excitement, wild reports flew through the city that an incendiary meeting was to be held, and an attempt made to burn the Pacific Mail Docks and Chinese quarter. The meeting was held, for the authorities soon saw that there was no reason for preventing it. There was no talk of lawlessness or allusion to the Chinese on the part of the promoters of the meeting or their speakers, but the excitement showed itself by the raising, on the outskirts of the immense crowd, of the cry, "To Chinatown!" a movement promptly stopped by the police; and in remoter districts some Chinese wash-houses were raided by gangs of boys. The papers—sensational to the last degree—made the most of this the next morning, and, in the excitement that the Eastern news had created, a meeting, held in the rooms of the Chamber of Commerce, organized a Committee of Public Safety, with the President of the Vigilance Committee of 1856 at its head, the hint being probably given by a telegram that the citizens of Pittsburgh had restored order by organizing a force armed with base-ball bats. In San Francisco the pick-handle was chosen instead, and for some days a large number of men so armed perambulated the streets. Space will not permit, nor is it necessary, to tell the story of this "battle of the kegs." Ridiculous in some of its aspects, it was serious in others. There was not the slightest necessity for this extra-legal organization and parade ; but, while San Francisco was represented to the world as a city on the verge of riot and anarchy, a strong feeling of class irritation was engendered.

Among those who carried a pick-handle in this "pick-handle brigade," as it was christened, was an Irish drayman, who has since become famous. Dennis Kearney, a man of strict temperance in all except speech, had built up a good business in draying for mercantile houses, and accumulated, besides his horses and drays, a comfortable little property. Up to this time he had taken no part in politics, except to parade in torchlight processions as a "Hayes Invincible," but for some two years had been a constant attendant at a sort of free debating club, held on Sunday afternoons, and styled the Lyceum of Self-Culture, where he had gradually learned to speak in public, though the temperance which he practiced and preached as to liquor and tobacco did not extend to opinions or their expression. He was noticeable not merely for the bitter vulgarity of his attacks upon all forms of religion, especially that in which he had been reared, the Catholic, but for the venom with which he abused the working classes, and took on every occasion what passed for the capitalistic side. With all the vehemence with which he has since inveighed against "thieving capitalists" and "lecherous bondholders," he denounced the laziness and extravagance of workingmen, declared that wages were far too high, and defended Chinese immigration. Whether, with the suddenness not unnatural to such extremists, Kearney really changed his opinions while carrying his pick-handle, the change being hastened by some recent losses in stocks, or whether he merely realized what political possibilities lay in the general feeling of discontent and irritation, and how easily in times of excitement men may be organized, makes little difference. He laid down his pick-handle, to put his drays in charge of a brother, and go into politics.

His first appearance in his new vocation attracted no attention. The Safety Committee excitement passed immediately into the excitement of the impending legislative and municipal election. Besides the regular parties, a number of independent organizations or "side-shows" were in the field, many of them consisting only of a high-sounding name and an Executive Committee, who found their account in nominating candidates from the principal tickets and assessing them for election expenses, candidates who were spending money heavily, preferring to pay something to get on even the most insignificant ticket rather than risk the loss of the few votes that might determine their election. Amid all these "parties," and "councils," and "clubs," the organization of a "Workingmen's Trade and Labor Union," with one J. G. Day as president and one D. Kearney as secretary, attracted no attention. This new organization, which, besides a president and secretary, boasted also a treasurer, stretched out a canvas bearing its name, and "resoluted" upon the necessity of "patriotism and integrity in the public offices from the lowest to the highest," calling upon the laboring classes to unite "to elect candidates in whom they can put their trust, and who are above suspicion." This being done, the new organization, by its president and secretary, proceeded in the usual way to ascertain which of the principal candidates were most above suspicion; but it printed no ticket, this particular movement to secure "patriotism and integrity in the public offices" winding up on the night before election in a row in which the treasurer and sergeant-at-arms vainly endeavored to make the president and secretary "come to a divide" on the amount collected, which they charged was between one and two thousand dollars.

But the master spirit of the ephemeral organization that thus unnoticed closed its life of weeks was no ordinary "price club man," who when one election is over retires from politics until the next approaches. The knot of men who had called the meeting of sympathy with the Eastern strikers had afterward organized a workingman's party and run a few candidates with a view to the future, but their intentions were brought to naught by the more energetic and audacious Kearney, who went to work without delay. On the Sunday after the election he again attended, for the last time, the Lyceum of Self-Culture, and, to the astonishment and amusement of the men whose ideas about the rights and wrongs of the working classes he had been berating, told them that they were a set of fools and blatherskites, and that he now proposed to start in with the demand of "bread or blood," and organize a party that would amount to something. The first move was a meeting to consider the Chinese question, at which a speech was made by a highly respected and prominent citizen; but when Kearney, who officiated as secretary, got the stand, he dealt out some more highly seasoned mental stimulant by reading a description of the burning of Moscow as a suggestion of what might be in store for San Francisco. Then appropriating the name of Workingman's party, Day and Kearney took to the sand-lot, enlisting some other speakers. Though violent, these harangues would have attracted little attention, and in fact the movement might have been choked in infancy (for several rival factions started up, and opposition platforms were erected within a few feet of each other), but for a powerful ally of just the kind needed.

The two San Francisco papers of largest circulation are the "Call" and "Chronicle," between whom intense rivalry has long existed. The "Call" has the greater circulation and more profitable business, drawn largely from the working classes. It is a good newspaper, but its editorial management is timorous to a ridiculous degree. The "Chronicle," whose principal proprietor recently lost his life in a tragedy growing out of these occurrences, is best described as a "live paper" of the most vigorous and unscrupulous kind. As though a tacit partnership had been formed, Kearney began to call upon workingmen to stop the "Call" and take the "Chronicle," while the "Chronicle" on its part advertised the meetings in the highest style of the art, giving Kearney the greatest prominence and detailing its best reporters to manufacture and dress up his speeches. Thus advertised, the meetings began to draw.

California Street Hill is crowned by the palaces of the railroad nabobs—men who a few years ago were selling coal-oil or retailing dry goods, but who now count their wealth by the scores of millions. To complete the block which one of these had selected for his palace, an undertaker's homestead was necessary. The undertaker wanted more than the nabob was willing to give, and the latter cut short the negotiation by inclosing the undertaker's house on three sides with an immense board fence, probably the highest on the Pacific coast, if not in the world. This veritable coffin, which shuts out view and sun from the undertaker's little home, and which the common law, now abrogated in California by the code, would not have permitted, is one of the most striking features of the Hill.

When, with the assistance of the "Chronicle," the meetings had begun to draw crowds, largely composed of unemployed men, who after the harvest begin to collect in San Francisco, and of a class that of late years has become numerous, the professional beggars or strikers, a meeting was called for the top of California Street Hill, where the nabobs were regaled by the cheers of a surging crowd, when it was proposed by one of the speakers—a pamphleteer and newspaper writer well known in California for many years, but who neither before nor since took any other part in the agitation—to celebrate Thanksgiving by pulling down the big fence, if not removed by that time. This was too much: the railroad magnates were frightened—even the "Chronicle" demanded the arrest of the agitators; a sudden energy was infused into the authorities, and they, with the proposer of the fence-destruction, were arrested on charges of riot.

That these arrests were ill advised the sequel proves. And it is to be remarked that in all Kearney's wild declamation there has been no direct incitement to violence. He has talked about wading through blood, hanging official thieves, burning the Chinese quarter, and generally "raising Cain," but it has always been with an "if." He has never come any nearer to actually proposing any of these things than Daniel O'Connell did to proposing armed resistance to the English Government. Nor yet is it easy to point to anything which Kearney has said that is really more violent or incendiary than things said before with impunity. It was not Dennis Kearney, but a Republican leader, a man of wealth, ability, and influence, who has held high position, and was this year a prominent member of the National Republican Convention, who first proposed that the Pacific Mail steamers should be burned at their docks if they did not cease to bring Chinese; it was a bitter opponent of Kearneyism who, amid thunders of applause, in the largest hall of the city, first suggested that the Chinese quarter should be purified with fire and planted with grass; while as to bitter denunciations of parties, classes, and individuals, and prognostications of violence and calamity if this, that, or the other was or was not done, there is probably nothing that Kearney or his fellows have said that could not be matched from previous political speeches or newspaper articles. That dangers may sometimes arise from an abuse of the liberty of speech may be true, but it is so exceedingly delicate a thing tc attempt to draw any line short of the direct incitement to specific illegal action, that the only course consistent with the genius of our institutions is to leave such abuses to their own natural remedy. It is only where restrictions are imposed that mere words become dangerous to social order, just as it is only when gunpowder is confined that it becomes explosive. Had the energy of the authorities been reserved for any lawless act, and these agitators been left to agitate to their full content, except so far as they might interfere with the free use of the thoroughfares, any momentary interest or excitement would have soon died out, and the contempt which follows swelling words without action would soon have left them powerless. But the timidity which attaches to great wealth gained by questionable means, and at once arrogant in its power and keenly sensitive of the jealousy with which it is regarded, renders its possessors, surrounded as they must be by sycophantic advisers, insensible to reason in moments of excitement. "The thief doth fear each bush an officer." And the man who from the windows of a two-million-dollar mansion looks down upon his fellow citizens begging for the chance to work for a dollar a day can not fail to have at times some idea of the essential injustice of this state of things break through his complacency, while murmurings of discontent assume vague shapes of menace against which fear urges him to strike, though reason and prudence would hold back a blow which can only irritate. The dangers to social order that arise from the glaring inequalities of wealth come as much from this direction as from the discontent of the less fortunate classes. It was this feeling that, organizing the "pick-handle brigade," prepared the way and gave the hint for agitation; it was this feeling that, now striking blindly through the authorities, gave to that agitation dignity and power.

More efficient means to provoke a public sentiment in favor of the agitators could not have been taken. Not only were the speakers arrested on charges which would not bear legal scrutiny, but new warrants were sworn out as quickly as bail was offered. A pledge made by the agitators in prison, to hold no more outdoor meetings and use no more incendiary language if the charges against them were dismissed, was refused, and special counsel were employed to prosecute. Outside the prison the same drunken spirit of arbitrary repression showed itself, not only by driving crowds from the streets, but by breaking up indoor meetings and installing captains of police as censors.

The reaction was swift and strong, but it was not at first heeded. The charges against the agitators were dismissed by the judge before whom they were brought, but fresh charges were made, which were dismissed by juries. An ordinance was rushed through the Board of Supervisors, under which it has never been dared to bring an action; a ridiculously oppressive law was hurried through the Legislature, which was similarly a dead letter, and which at the next session was repealed without a dissenting voice and hardly a dissenting vote.

These impotent attempts at repression produced their natural result. The new party was fairly started, brought into prominence and importance by the intemperance which had sought to crush it.

The feeling on the Chinese question has long been so strong in California as to give certain victory to any party that could fully utilize it. But the difficulty in the way of making political capital of this feeling has been to get resistance, since all parties were willing to take the strongest anti-Chinese ground. But the fear that the agitators had evidently inspired, the effort to put them down, served as such resistance; and, though all parties were anti-Chinese, the party they were endeavoring to start became at once *the* anti-Chinese party in the eyes of those who were bitterest and strongest in their feeling, while it at the same time became an expression, though rudely and vaguely, of all sorts of discontent. It was evident that it would be a political power for at least one election. The lower strata of ward politicians went rushing into it as a good chance for office; the "Chronicle," which, at the first symptom of reaction, had redoubled its services, placarded the State with resolutions of the new party asking workingmen to stop the "Call." That paper, losing heavily in subscribers, quietly began to outdo the "Chronicle" in its reports and its puffery. Other papers, recognized as organs of interests popularly regarded with dislike, did their utmost by denunciation to keep Kearney in the foreground. Republican politicians saw in the movement a division of the Democratic vote worth fostering; Democratic politicians saw in it an element of future success, on the right side of which the political wise man would keep; the municipal authorities, remembering coming elections, passed from persecution to obsequiousness; while the great railroad interest either came to a tacit understanding, or had its agents install themselves in the new organization,* using it to help their friends

* There have been no more meetings on Nob Hill, or denunciation of the railroad magnates or great bonanza firm. On the contrary, all the officials elected by the workingmen seem to have been either employees or friends of the railroad, or people who

and keep out their enemies, as they aim to use, and generally succeed in using, all parties, and men of high social standing did not hesitate, when it served their purpose, to furnish points and matter for sand-lot harangues, or to speak at meetings which Kearney and his gang had captured; for, until they met a very warm reception at a Democratic meeting, they arrogated to themselves the right to interrupt and "bull-doze" any meeting that did not suit them.

Kearney had quickly come to the head of the movement, changing his first place of secretary for that of president shortly after taking to the sand-lot, and having, by the time he and his companions emerged from jail in triumph, got so well to the head as to become in the popular eye its representative and embodiment. He showed great address in keeping the place. The organization which he managed to give the new party was admirably designed for this purpose. The weekly assemblage on the sand-lot, where anybody could shout and vote, was recognized as the great parliament and plebiscitum, and in the State conventions, in which the country as well as the city clubs were represented, the supremacy of the city clubs was provided for by the interdiction of proxies. As president of the party (something new in American politics, but an idea probably borrowed from the Committee of Public Safety), Kearney was anything but a mere figure-head. He has seemed to see, as clearly as any philosophical student of history has seen, the true spring and foundation of arbitrary power—the connection between Cæsar and the proletariate.

He appeared on all occasions in rough working-dress; he announced that he would take no office, but, as soon as he had led the people to a victory, he would go back to his dray, and must in the mean time be supported by collections, for which he passed around the hat at every meeting. These things, the style of his oratory, the prominence he had attained, his energy, tact, and temperance, gave him command of that floating element which will travel around to the most meetings and do the loudest shouting. And, commanding this, he commanded his party.

Presiding at the sand-lot, he claimed the right to say who should speak and to put all questions, and, traveling around from club to club, accompanied by a crowd of admiring followers, who voted just as the Parisian rabble did in the Revolutionary clubs and conventions, he took possession wherever he went. Availing himself of the feeling against politicians and political chicanery, he declared parliamentary law to be political trickery, and put motions as he pleased, or didn't put them at all, and for him to denounce any mutineer as a politician was to doom him to immediate "firing out." This was the fate, one after the other, of all the men who had begun with him the agitation, and of all those who from time to time began to gain any prominence which might

could not harm them, while a confidential attorney of large moneyed interests has been the reputed confidential adviser of Kearney.

endanger his supremacy. By a single *coup d'état* he swept out the whole Central Committee the moment they began to show a disposition to have some voice in the management of the party, alleging, as was naturally the fact, that they were candidates for office. No one was allowed to enter who had talent or influence enough to become a rival; no one was allowed to speak who would not constantly belaud "our noble leader"; and the men whom he selected as his lieutenants and allowed to come to the front were, without exception, not only men who accepted of these conditions, but men who for some reason or other stood in such relation to the controlling element of the party that he could at any time he chose turn on them and fire them out.* By this denunciation of politicians, by thus striking down every head that raised itself in his organization, he not only appealed to prejudice and jealousies, but to the personal interest and ambition of the club membership. The political hewers of wood and drawers of water, who made up the clubs, flattered themselves with the idea that *they* were the men of whom sheriffs, and supervisors, and school-directors, and Senators, and Assembly-men were to be made, and they brought to the new party and to the support of Kearney all the enthusiasm which such a hope called forth.

It may seem strange that a party thus constituted and led should poll such a heavy vote. But in our large cities, and progressively in the country as a whole, the active managing portion of a party bears a very small proportion to the vote which it polls. In New York or Philadelphia, as in San Francisco, but a handful of men make the tickets between which, on election-day, the majority of voters must choose. So in this case the heavy vote came from people who never joined the clubs or visited the sand-lot—from people who were so utterly disgusted with the workings and corruptions of old parties as to welcome "anything for a change."

And this feeling was greatly intensified by a train of occurrences which called attention to the prevailing corruption. Kearney's tirades against daylight robbers and official thieves had a basis of fact. To say nothing of bank-failures and stock-swindles, it came to light that brokers were engaged in selling positions on the police; that the questions upon which the teachers in the public schools are appointed and promoted were regular articles of merchandise; and that, running through successive administrations, the most enormous stealing had been going on in street improvements. Three important municipal officials committed suicide, one after another, and, behind all that came

* To illustrate what I mean, the man whom Kearney made vice-president, and who assumed his place during his absence, was an unnaturalized Englishman, who had been a sort of anti-Catholic missionary, and who could for this and other reasons get no lasting hold upon the Irish, of whom the active party was largely composed, and whom, when Kearney finally chose to, he flung aside without the slightest trouble. This was not an exception, but the rule.

to light, there was a mass of corruption never to be developed, for justice in San Francisco, as in some other places, seems stricken with palsy in presence of rich criminals and powerful rings.

The only remedy which the new party offered for this state of things was the usual remedy, "Elect honest men to office, we naming the honest men;" but in the beginning Kearney proposed the additional safeguard of hanging officials who broke their pledges. And, at the first election in which the new party engaged—to fill a vacancy in the legislative representation of the strong Republican county of Alameda, where the railroad interest is very powerful, and the population consist largely of San Francisco business men—the workingmen's candidate, a railroad employee named Bones, went around with a halter about his neck in token of his acceptance of this condition. He was elected, took his seat, and immediately began voting just as he had promised not to. There was enough discussion of how he should be hung to make him ask the protection of the Senate, but there was no hanging. This ended faith in that guarantee, but not in pledges, the municipal officials subsequently elected by the workingmen in San Francisco being pledged to draw only half salaries—a pledge which after election they one and all ignored as easily as before election they had taken it.

But, before the feelings which had been aroused by the events of which I speak could spend themselves in a general election of officers, there came, in June, 1878, the election for delegates to a Constitutional Convention. This whole subject of the new Constitution of California is extremely interesting and suggestive, but I can only allude to some main features. The large corporate interests took advantage of the situation, by starting a movement for a "Non-Partisan" ticket, on which, of course, they got a good representation. If they did not also engineer the Workingmen's nominations, they could hardly have done better, as these consisted generally of men utterly ignorant and inexperienced. The "Non-Partisans" carried the State at large, the Workingmen San Francisco and some other centers where they had organizations. The Convention itself was vaguely divided into three groups: first, the lawyers, who largely represented corporation interests; second, the "Grangers," who represented the ideas and prejudices of the farmers and landholders; third, the Workingmen, bent on making capital for the new party, and desirous of doing something for the laboring classes, without the slightest idea of how to do it. But there was nothing in the Convention like agrarianism or socialism, or radical reform of any kind. The lawyers looked out pretty well for their special interests; the Workingmen, satisfied with some clauses about the Chinese, etc. (not worth the paper on which they were written), readily fell in with the Grangers, imagining that, in piling taxation upon capital and all its shadows, they were helping the poor by taxing the rich. The resulting instrument is a sort of mixture of constitution, code, stump-speech, and mandamus. But it is anything but agrarian or communistic, for it intrenches vested rights—especially in land—more thoroughly than before, and interposes barriers to future radicalism by a provision in regard to amendments which it will require almost a revolution to break through. It is anything but a workingman's Constitution: it levies a poll-tax without exemption, disfranchises a considerable part of the floating laboring vote, introduces a property qualification, prevents the opening of public works in emergencies, and in various ways, which workingmen, even in their present stage of enlightenment, may easily see, sacrifices the interests of the laboring classes, as well as the capitalist, to what the land-owners regard as their interests, while in other respects its changes, which are in the same direction as other late constitutions, are out of the line of true reform.

But anything like calm discussion of the work of the Convention became impossible. The moneyed classes of San Francisco, taking alarm at the taxation clauses, raised a fund of some hundreds of thousands of dollars to defeat the new Constitution, which was placed in the hands of the head lobbyists of the railroad company, and a regular bureau opened, while threats of the discharge of employees and withdrawal of patronage as penalty for voting for it were freely made. If, as believed by many, large special interests were engaged in the support of the new Constitution, they had the intelligence to work quietly. On the surface it seemed as if every tyrannous and corrupt influence was united for its defeat. In the torrent of passion which raged, it is difficult to say whether those who opposed or those who advocated the new Constitution said the most absurd things. On the one side it was denounced as a "communistic" instrument which would bring every calamity, on the other it was advocated as "the Magna Charta of the laboring classes." The real agrarians and communists, if these terms be applied to men who desire fundamental changes, opposed the new Constitution all they could. But the fact that enormous sums were being spent to defeat it, subjected every one who opposed it to the imputation of being the hireling of anti-popular interests. And so, with the solid vote of the farmers, aided largely by the vote of those who lose most by it, the new Constitution was carried.

In this contest the Workingmen had become, as in the Convention, a sort of tail to the Grangers' kite, and Kearney had to a great extent been forced into the background, while a number of old "war-horses" came to the front. The "Chronicle," which had made a vigorous fight for the new Constitution, saw in this combination an opportunity to make a new party of its own which should fill all the offices under the new instrument, and Kearney was given to understand that he might now retire on his laurels. This he very vigorously declined to do, and war between the late allies commenced, the "Chronicle" printing with little immediate effect long exposures of the man it had so much lauded, and Kearney denouncing the New Constitutionalists as "Honorable Bilks," a name which derived its significance from the number of ex-Honorables in their ranks, and which stuck so tightly that they even began to speak of themselves as "the Bilks." As showing how much agrarianism there is in the new Constitution, the candidate of that party for Governor, an ardent supporter of the instrument, is the largest farmer in the State, the owner of something like a quarter of a million acres!

Both Republicans and Workingmen ran State tickets, while the Democratic party degenerated into a sort of "price club," ready to trade nominations with anybody who would make a combination. In this three-cornered contest the Republicans carried the State by a plurality, except where the other parties were united on the same candidate, and except as to San Francisco. Here the Workingmen's ticket was headed by the Rev. Dr. Kalloch, a leading Baptist clergyman well known at the East, and of great ability as a stump-speaker, who in the beginning of these events had the largest Chinese Sunday-school in the city, and preached the virtues of dealing with mobs by loading with grape and firing low, but who, when the movement assumed political force, shut up his Chinese Sunday-school and preached in such a different key that he completely captured the Workingmen, and was finally (though not by Kearney's wish) nominated by them for Mayor. The crack of De Young's pistol from behind the curtain of a *coupé* fired Dr. Kalloch into the mayoralty and gave the Workingmen several municipal officers and a number of members of the Legislature, besides such candidates as had united their nomination with that of other parties. But about none of the men thus carried into office in whole or in part by the Workingmen's vote is there anything socialistic or communistic. They are merely ordinary office-seekers who took advantage of the Workingmen's organization as giving a certain vote, and who, though generally they would have endorsed communism had it been popular, would have done so no quicker than they would have endorsed imperialism or Mormonism or spiritualism or vegetarianism.

After this election, and during Kearney's absence in the East last winter, began a new movement which, however, did not emanate from the Workingmen's party proper, and was led by new men—the meeting and marching of the unemployed, demanding of large employers the discharge of the Chinese. The alarm this excited, until the advance of the season and the consequent demand for laborers in the interior had lessened temporarily the number of unemployed, led to the reorganization of a Committee of Safety, which enrolled a good many names and spent some money in paying the militia to guard their arsenals,* but

* A job which the jovial sons of Mars rather liked, as it gave them three dollars per night for privates and five dollars for officers, and the necessity for which of course they did not belittle. In fact, in some of the night watches such expedients for continuing the excitement as getting on the outside and chucking bricks through the windows were discussed, if not put into practice.

made no parades. To this organization, however, I do not attribute the defeat of the Workingmen in the March election in San Francisco for a joint Senator and freeholders to frame a charter. It was in the natural course of things that the Workingmen should be beaten, even though the Democratic organization endorsed their candidate for Senator and nominated no freeholders. For a party without national affiliations or definite aims must die with its first success, and this is peculiarly a party that has been only kept alive by the mistakes of its opponents.

That Kearneyism had run its course was clearly evident in San Francisco after this election. The new Constitution has proved a bitter disappointment to those who expected so much from it; the officials elected by Workingmen have proved no particular improvement; disintegration was fast showing itself in the clubs, and Kearney was rapidly losing his popularity and influence with the class that had followed him. But a perceptible check was given to this decline when Kearney was sent to jail and fined a thousand dollars for an offense ordinarily punished by a trivial fine when punished at all. Thus made a victim, Kearney every day he staid in jail was gaining in popularity and strength as he had before, and when released by the Supreme Court was drawn in triumph through the streets on one of his own drays.

This brief sketch, though necessarily very imperfect, will accomplish all I intend if it makes the general facts and course of this agitation sufficiently intelligible to enable thoughtful men to see its true relations and real meaning. That a rude, uncultured drayman, with no previous influence over any class, should acquire such notoriety and wield such power, that a great city should so long have been kept in a state of excitement, are phenomena which more imperatively demand that careful and dispassionate attention which we call scientific than any conjuncture of the planets or appearance of spots on the sun. For, while we know that during unnumbered ages this great celestial machine has pursued its orderly movements, we also know that, while day has followed night and harvest succeeded seed-time, human society has been subject to the most terrible perturbations and cataclysms. And what has been going on in California betokens the social unrest and discontent from which destructive forces are generated.

That these events do not spring from exotic or abnormal causes seems to me clear. This agitation is not the result of the importation of foreign ideas, but the natural result of social and political conditions toward which the country as a whole steadily tends, and its development has been on lines strictly American. Kearney is not a type of the fanatical reformer, but of the politician, and possibly in a rough sort of way, not of the "coming Cæsar" of whom we hear so much, but of the real Cæsar whom we may one day evoke; the workingman's movement has been essentially nothing more than an ordinary political movement growing from and taking advantage of popular discontent ; while the new Constitution of California, destitute as it is of any shadow of reform which will lessen social inequalities or purify politics, exhibits the same tendencies as the newer constitutions of other States.

That Kearney or any considerable number of his followers ever seriously thought of an appeal to force, either to get rid of the Chinese or for any other purpose, I have not the slightest idea. The workingmen's military companies, of which a few were formed, would not have been at any time a flea-bite to the strong and well-appointed militia of the city, and were merely an amusement—a sort of set-off and imitation of the Committee of Public Safety. And it must be remembered that these vague suggestions of violence not only, as I have before said, secured resistance which turned latent force into political power, but the agitation did considerably check Chinese employment and immigration, while the passage of an anti-Chinese bill by Congress (though this bill was denounced at the time by Kearney), was claimed as one of its results.

And though capital has been frightened, at times seriously frightened, by this agitation, it must not be thought that this fright has been shared by all the property classes. On the contrary, the inner and influential circle of Kearney's backers and supporters have been men of more or less property, and large moneyed interests have sought to use the movement. Neither in platforms nor candidates has there been any leaning to the questioning of property rights. One Parisian communist was elected to the Convention, but he exercised no influence, and was expelled from the party for refusing to support the new Constitution. But, with this exception, the Workingmen's candidates have been no more radical than the average of American politicians. At the last election, for instance, their ticket was headed by a graduate of the University of California, who has been prominent in the party since it first assumed importance, and one of its candidates at every election. He belongs to a Jewish family who do a profitable manufacturing business, and not only disclaimed anything like socialism or agrarianism, but appealed to the corporation lawyers with whom he served in the Convention to certify to his conservatism. And next to him came a rich land-owner who has given a hundred thousand dollars for the establishment of a law-school, of which he is dean. What Kearney and his party have practically proposed has been merely the remedy which their preachers, teachers, and influential newspapers are constantly prescribing to the American people as the great cure-all—elect honest men to office, and have them cut down taxation ; a remedy which belongs to the same category as the recipe for catching a little bird by sprinkling salt on its tail !

Now, I do not mean to say that there has been nothing in this movement to excite alarm ; that the classes whose fright has led them into foolish actions have been frightened entirely by their own shadows; or that, if by communism is meant a blind bitter irritation with things as they exist, there has not been communism in it. On the contrary, at the bottom of all this is deep social and political discontent. It is not radical, because it is not intelligent. It has been willing to follow those who promised really nothing; it has demanded only quack remedies because it is ignorant. But it is this that makes it dangerous. Ignorance, inflamed by passion, is the most terrible and destructive of monsters. The *Jacqueries*, the massacres, the reigns of terror, the revolutions which have overthrown one tyrant only to put a worse one in his place, have not been the work of those intelligent enough to see that social and political evils arise from wrong systems, but of those who, not quarreling with systems, charge the evils from which they suffer upon the wickedness of individuals or classes.

Had this movement involved anything which could properly be styled socialistic or communistic, it would have seemed to me hopeful, for socialism and communism involve some sort of theories which show at least a groping for real remedies. But what seems to me ominous in all these events is, that they show how easily our political struggles may pass into all the bitterness and dangers of excited class-feeling without calling forth any principle of improvement or reform. There is a comfortable belief widespread among us that, under a popular government, social and political evils tend to cure themselves by arousing the attention of the people. This would be true if, when the people became conscious of an evil, they stopped to think about its cause and its cure instead of following the first demagogue who, flattering their prejudices and appealing to their passions, promised them a cure. But this is not the lesson of history, nor yet does it seem to me the lesson of observation. What has been passing under my eyes has, with much greater vividness and force than I can convey in such a brief sketch, appeared to me to show the play of the same forces that have over and over again brought despotism out of freedom, anarchy out of order, and turned progress into retrogression. Popular government is not a new thing. All government in its beginning must have been popular government. And under all forms of government the people are the source of power. The force with which despots and tyrants, enslavers and destroyers, have worked has always been the force of the people themselves. *Vox populi vox Dei!* If that means anything more than that majorities are the source of power, it is as absurd a superstition as the faith in Mumbo Jumbo.

The danger to social order is not a direct one. The forces that would rally at any open assault upon it have with us overwhelming strength. The real danger comes through forms of legality and methods of government. Tweed and his little band would have been lodged in jail in a trice had they directly attempted their robberies; yet Tweed and his handful for years levied at their will upon the wealth of New

York and flaunted their spoils in all men's eyes. The man who now talks about wading through blood and hanging people to lamp-posts is but the vender of a nostrum who dresses as a wild Indian to attract attention ; but when blind fear and unreasoning resentment sway the Government, and give to whoever can arouse them the prizes of place and power, the day when blood will flow and cities burn may not be so far off. There has never yet been any danger of mob violence in San Francisco; and yet, watching what has been going on there, it has seemed to me that I could see how jealousy and fear and hatred and revenge might mount through a series of actions and reactions to the point where reason is utterly trodden under foot ; that I can understand better than before how faction piled the streets of Jerusalem with corpses, while Titus thundered at her gates ; how the colors of circus-charioteers divided Constantinople into two hostile camps ; how the reappearance of French liberty ushered in Red Terror and White Terror. It is true that we have the public school and the daily paper ; that any child can tell you the distance of the sun, and how this system once rolled a mass of incandescent vapor. But, "scratch a Russian and you have a Tartar." Look at your civilized man when fired by that strange magnetic impulse which passion arouses in crowds, and you may read in his eyes the blind fury of the Malay running amuck. You will understand how handkerchiefs hemmed with the sewing-machine might be dipped in blood, and hearts carried on pikes through streets lit with gas !

Aristocracies, hierarchies, established orders, hereditary castes, and strong religious beliefs that have become conservative, they are like the trees and the fences that check the violence of the blast that over a dead level rushes in headlong fury—like the ballast in a ship that resists the sudden lurch. But these we have cast off or are casting off. Government with us grows in weight and importance ; but this is not a conservative force when its increasing powers and emoluments are to be grasped by whoever can best organize corruption or rouse passion. We have great and increasing accumulations of wealth ; capital is becoming organized in greater and greater masses, and the railroad company dwarfs the State. But these are not forces of stability. Perhaps these great combinations are forced into politics in self-defense. But, however they get there, their effect is but to demoralize and corrupt—to reward and to bring to political leadership the unscrupulous. And these great corporations themselves are but the prize and prey of adventurers, the fattening-places of unscrupulous rings.

Given universal suffrage ; a vague, blind, bitter feeling of discontent on the one side and of insecurity on the other ; unscrupulous politicians who may ride into power by exciting hopes and fears ; class jealousies and class antipathies ; great moneyed interests working through all parties with utter selfishness ; a general disgust with political methods and feeling of practical political impotence, producing indifference and recklessness on the part of the great mass of voters—and any accident may start a series of the most dangerous actions and reactions. Such a community is like a ship with an ill-stowed cargo. In light winds and smooth water all may seem secure; but in the strain of a heavy sea what should be the element of stability becomes an element of danger, and may throw her upon her beam-ends or tear her to pieces.

What has been going on in California is not out of the natural course of things. The forces that have produced these events have been developed, not imported. And as it seems to me that the same forces exist in other parts of the country, I can not see why, essentially, the same movements may not soon begin elsewhere. It is this that makes these California experiences worthy of attention. Every result becomes in turn a cause; every event is the progenitor of future events. And it is probable that this California agitation marks the beginning of a new phase in our politics. Whatever be his future career, Kearney has already made what will be regarded by thousands and thousands of men, many of them of much greater abilities, as a dazzlingly brilliant success. An unknown drayman, destitute of advantages, without following or influence, he has, simply by appealing to popular discontent and arousing the uneasy timidity which is its correlative, risen to the rank of a great leader, and drunk the sweets of power and fame. He knows what it is to be the hero and the master of surging multitudes; to draw forth their applause by a word, to hush them into silence with a wave of his hand; to be garlanded with flowers; to be drawn in triumph through crowded streets; to be attended wherever he went by a retinue of reporters and correspondents; to rise every morning to find the newspapers filled with him; to have men, who would not have noticed him had he stuck to his dray, slink by night to his house, or solicit his favors by go-betweens; to look upon high officials as the creatures of his making; to be known and talked about, not merely through the whole country, but over the world! Whatever becomes of Kearney—and it would be rash to predict that his career is yet over—this lesson will not be lost: The wave rises, curls, and subsides, and, where was its white crest, are but some spumes of foam. But the impulse is perpetuated, and another wave swells up.

When, under institutions that proclaim equality, masses of men, whose ambitions and tastes are aroused only to be crucified, find it a hard, bitter, degrading struggle even to live, is it to be expected that the sight of other men rolling in their millions will not excite discontent? And, when discontented men have votes, is it to be expected that the demagogue will not appeal to the discontent, for the sake of the votes? It is useless to blink the fact. Nothing is clearer, to whoever will look, than that the political equality from which we can not recede, and the social inequality to which we are tending, can not peacefully coexist. Nothing is surer than that all the inventions, and improvements, and discoveries, of which our time is so fruitful, are tending with irresistible force to carry mere political democracy into anarchy.

All these evidences of growing social and political discontent, all these agitations and disturbances—the more violent talk on the one side, the leaning to repression on the other—are indications of unstable equilibrium, of a maladjustment of powerful forces. It is *the* necessity of the time—the vital, pressing necessity—that these phenomena receive the careful, conscientious attention of thoughtful men, who will trace them to their source and popularize the remedy. It will not do to leave them to the ignorant poor and the ignorant rich, to politicians and demagogues. They require the scientific spirit and the scientific method ; they demand the thought of those who can think, and whose opinions carry weight.

THE INTERIOR OF THE EARTH.*

By R. RADAU.

II.

ASIDE from the evidences of the earth's internal heat furnished by artificial excavations, we have incontestable proof thereof in hot springs and in volcanic phenomena generally. The temperature of certain springs is nearly 100° at the surface. That of the Chaudes-Aigues is 80° ; the Trincheras (Venezuela), 97° ; the geysers of Iceland are 85° at the surface and 127° at a depth of twenty metres. But it is plain that the temperature of hot springs does not necessarily indicate the heat of the depths they come from. Aside from purely chemical agencies, there are physical causes sufficient to account for a very high degree of heat. When we consider the size of such caverns as those of Carniola and Istria, it will not be difficult to believe that there may be in the earth's crust fissures ten or twenty kilometres in depth, that may be filled with water, like the cavity that periodically absorbs and expels the water of the Lake of Kirknitz. Even at a depth of two or three kilometres the temperature of this water is 100°, but the pressure of two or three hundred atmospheres which it sustains prevents ebullition, as at 100° steam attains a pressure equal to the weight of only one atmosphere, and it does not form unless the pressure exceeds that. Under stronger pressure a higher temperature is required before ebullition takes place (i. e., the temperature at which the pressure of steam equals the resistance, or pressure on the liquid). Thus, under a

* Translated from the "Revue des Deux Mondes," by Guy B. Seely.

pressure of 10 atmospheres, water boils at 180° ; under 25 atmospheres at 225° ; beyond these limits the law that governs the phenomenon of ebullition is not accurately known, but it is known that the pressure of steam increases in a much more rapid ratio than the temperature, and it may be stated that it approximates to 1,200 atmospheres at about 600° ; 5,000 atmospheres at about 1,000°, etc. From this it is clear that there is a point where the pressure of steam will equal the weight, where consequently ebullition will occur. Admitting that the temperature of the soil increases at the rate of 1° to 20 metres, we would reach at twelve kilometres a temperature of 600° ; and at this depth the pressure of steam would equal the resistance. It would be necessary to go deeper if we adopt a less rapid rate of increase in temperature. Now, if water commences to boil beneath a certain level, the steam will rise through the mass and condense anew, as in a refrigerant imparting thereto a portion of its heat. The upper portion of the liquid will thus become heated more than the soil at the same level ; in fact, the water may boil even at the surface, as in the Iceland geysers.

If, in volcanic regions, the temperature is 1,000° at about twenty kilometres depth, the steam forming at that point may possess a pressure greater than 5,000 atmospheres—which would be sufficient to sustain the weight of a column of lava twenty kilometres high. At a temperature of 1,300° the pressure would doubtless be equal to 10,000 atmospheres. This is very nearly the force of the gas of gunpowder in a cannon of heavy caliber, and it is evident that this force would more than suffice for the mechanical effects of which volcanoes offer the terrifying spectacle.

However we view it, volcanoes are an irrefragable proof of a subterranean fire ; they truly seem to be the thousand gates of the burning hell we read of. The number of volcanoes discovered constantly increases with the progress of geographical knowledge ; in the least explored countries highly volcanic regions are found. A. von Humboldt enumerated 407, of which 227 were active. We now know of several thousand, and, according to M. Fuchs, the number of active volcanoes at the present time may be set down as 323. It is difficult to draw the line between active and extinct volcanoes, because the greater portion have periods of repose, possibly a century or more in length. We know that the ancients considered Vesuvius a perfectly harmless mountain up to the time of the great eruption of A. D. 79, when Herculaneum and Pompeii were buried, and that it remained quiet for three centuries (1306–1631).

On looking at a map whereon the volcanoes are marked as red points, the attention is at once struck by the fact that almost all are found in proximity to the large bodies of water. The greater number are found to be on islands ; and the remainder, with a very few exceptions, near the borders of the sea or of lacustrine basins. Around the

Pacific Ocean is a vast circle of ignivomous mountains — the western coasts of America, the Aleutian Islands, Kamtchatka, the Kuriles, Japan, the Philippines, Molucca, down to the Sunda Islands and New Zealand, being comprised therein. Aside from this immense belt only isolated groups are found, but they are always disposed around the borders of the sea, or near some large body of water. Does not this geographical distribution force us to the conclusion that there exists an intimate connection between volcanic phenomena and water? Shall not we say that infiltration of water is a necessary condition of eruptions, and that the force which expels the torrents of lava is due to the pressure of steam?

This view finds a confirmation in the recent discoveries of the chemical constitution of the gases emitted by volcanoes. According to M. Charles Sainte-Claire Deville, the clouds that emanate from volcanoes consist principally of the vapor of water. M. Fouqué estimated at over 2,000,000 cubic metres the quantity of water thrown out from Etna in a gaseous form during the eruption of 1865. The clouds of vapors issuing from a crater in eruption often condense and fall in deluge-like rains, which make torrents of mud of the volcanic ashes. The streams of lava are, moreover, so charged with vapors that they acquire a remarkable fluidity. These vapors are rapidly disengaged as the streams descend, and sometimes in suddenly escaping they occasion miniature eruptions in the middle of a torrent of solidifying lava. Marine salt and other elements of sea-water are found in the gaseous products of eruptions and in the deposits of fumaroles as well; and M. Fouqué's researches on the chemical composition of the emanations from Vesuvius, Etna, and the volcano of Santorin, show that they are in part the result of the decomposition of sea-water.

Such accumulated proofs no longer allow us to doubt the constant agency of water in the production of volcanic phenomena. It would seem that sea-water passes into the subterranean reservoirs either by percolation through fissures or by transudation under the enormous pressure it sustains. Coming in contact with the incandescent lava at a great depth, it is vaporized, and the accumulation of steam causes from time to time an explosion of these subterranean boilers. Although the heat of the lava-streams is rapidly dissipated by contact with the air, the temperature of the incandescent mass at the bottom of the crater may be estimated at 2,000°, for refractory metals are known to melt in contact with the molten lava. Were it not over 1,200°, the pressure of the steam generated by matter thus heated would be ample to account for the explosive force of eruptions. It is not necessary, indeed, to assume so great a depth as twenty kilometres for the seat of this force, in order to explain the existence of matter in fusion, for there is nothing to militate against the supposition that the earth's crust is thinner in volcanic regions than elsewhere. It is quite probable that the inner surface of this crust is furrowed and fissured, especially along the lines of unequal density where the continents join the ocean-beds.

The quantity of lava that a volcano emits during an eruption surpasses anything we can imagine. The volume of the lava-stream of Kilauea, in the great eruption of 1840, was estimated at five and a half milliards of cubic metres, and a still larger mass was thrown out in 1855 from the crater at the summit of Mauna Loa, of which Kilauea is the smaller outlet. But these are trifling compared with the mass of matter emitted by the Iceland volcano of Skapta-Jökull, in 1783, which was estimated to equal the volume of Mont Blanc, or not less than five hundred milliards of cubic metres! According to the probably exaggerated estimate of Zollinger, the total volume of scoriæ and ashes thrown out in 1815 from a volcano in the island of Sumbawa (Tomboro), to the distance of five hundred kilometres, equaled twice that of Mont Blanc. We have more exact data concerning the eruption of Coseguina, a small volcano of Central America, which, in 1835, rained pumice-stone on the land and sea over a radius of fifteen hundred kilometres, and discharged daily not less than fifty milliards of cubic metres. When we consider the stupendous force required to raise and throw to a distance such volumes of matter, it is difficult to believe that the underground forces that feed the volcanoes, and which we know have been active from a very remote period, are mere accumulations of matter in fusion. Still more difficult is it to suppose that the heat of these fires is due to chemical action developed in the bosom of the earth. We can not but seek, in the wide-spread, incandescent mass under the thin crust that varies, possibly, from twenty to one hundred kilometres in thickness, the proximate cause of volcanic phenomena. The objection based on the non-coincidence of eruptions of volcanoes situated in the same region disappears when the mechanism of the eruption is explained by the more or less fortuitous deposition of infiltrated water.

The question appears to be reduced to deciding whether the central nucleus on which the mass of lava rests is itself liquid or whether it is solid. This is a much disputed point, and great ingenuity has been shown on both sides of the argument. The hypothesis of a liquid nucleus has long been favored, and it has many adherents. It has been objected that a liquid nucleus would be subject to tides that would break in an instant the thin envelope and produce terrific cataclysms. Ampère, in particular, felt it impossible to reconcile this consequence of the hypothesis with the calm that reigns on the surface. "Those who maintain the idea of a liquid nucleus," said he, "do not appear to have considered the effect of the moon's attraction on this enormous liquid mass, which would cause tides analogous to those of our seas, but far more terrible, by reason of their extent and the density of the liquid. It is difficult to conceive how the earth's crust could withstand the action of a kind of hydraulic lever 1,400 leagues long."

He therefore maintained, with Davy, the hypothesis of a non-oxidized nucleus which becomes an inexhaustible chemical source of heat by contact with the already oxidized crust. In this view of the matter, a volcano is simply a permanent fissure and channel of intercourse between the non-oxygenated nucleus and the liquids lying upon the oxygenated bed. Whenever this passage of the liquids to the nucleus takes place, elevations of the earth occur from the increase of volume due to oxidation. The heat generated by these chemical actions is propagated at once toward the exterior and interior of the globe, and, in proportion as the oxidation of the crust progresses, the seat of these chemical actions is carried deeper. This, a difficult theory to sustain, has no longer any adherents.

To the objection of the power of the tides it may be further said that, examined more carefully, they would probably be found to produce an entirely inappreciable flexion of the solid crust far from sufficient to cause any disruption. Indeed, it is a question to be considered whether earthquake phenomena do not indicate the existence of subterranean tides. This is a matter that has formed the object of over thirty years' researches by M. Alexis Perrey, Professor of the Faculty of Sciences at Dijon. Professor Perrey has compiled all the observations of earthquakes from the middle of the last century to the present time, and, in grouping the various facts collected during these one hundred and twenty-five years, he has been able to adduce evidence of a connection between the frequency of earthquakes and the phases of the moon. If the phenomena are compared with the lunar month, two maxima will be seen at the periods of the syzigia (new and full moon), and two minima during the first and last quarter. In the following table the results of observations for three periods are given, the earthquake-days being grouped in the weeks corresponding to the moon's four phases, the new and full moon groups and the quadrature groups being separated :

OBSERVATIONS.	FIRST PERIOD. 1751-1800.	SECOND PERIOD. 1801-1850.	THIRD PERIOD. 1843-1872.
Total number of earthquakes	3,655	6,595	17,249
During the syzigia	1,901	3,434	8,838
During the quadratures	1,754	3,161	8,411
Difference in favor of syzigia	147	273	427

It would thus appear that the shocks occur more frequently at those periods when the sun and moon can combine their action on the liquid particles of the interior of the globe.

M. Perrey has also compared the earthquake-periods with the times of perigee and apogee, that is, the moon's nearest point in her orbit to and farthest point from the earth. The following table gives the results of the comparison—periods of five days being taken—in the middle of which occurs a perigee or an apogee of the moon:

OBSERVATIONS.	1751-1801.	1801-1850.	1848-1872.
At perigee	526	1,223	3,290
At apogee	465	1,113	3,015
Difference in favor of perigee	61	110	275

A third means of ascertaining the moon's influence on earthquake phenomena consists in comparing the latter with the lunar day. There are then found to be two maxima corresponding to the moon's passage to the upper and lower meridian, or to what may be called the lunar mid-day and midnight. The minima occur near the middle of these intervals. M. Perrey has made comparisons in this way of 824 shocks felt at Arequipa from 1810 to 1845; of the journals of four observers at Monteleone, Messina, at Catanzaro and Scilla, in the years 1783 to 1785, which were marked by great eruptions of Vesuvius; and, lastly, of the journal of M. S. Arcovito, kept at Reggio from 1836 to 1854. There is manifest, more or less markedly, in all these observations, a preponderance in favor of the hours of the moon's passing the meridian.

This constant increase in frequency of the shocks at the times when the tides are strongest would seem to prove that the producing cause extends its action below the earth's surface. The increase is small, it is true, but it is constantly apparent, however the facts may be viewed.

We must not lose sight of the local perturbations to which the irregularity of the earth's internal surface may give rise. As M. Perrey has said, the lower side of this shell must consist of curves and anfractuosities, mountains whose summits project into the central liquid like gigantic stalactites, and valleys which approach the outer surface. This internal orographic system must modify the propagation of the subterranean waves. As in narrow and rapid rivers, the waves will be confined, and will gain in power between two mountains that obstruct their passage; they will spread out and lose power in a plain or valley whose configuration allows them to move more freely. Beating against cliffs and other obstructions, they will cause shocks and concussions, fissures, and a partial local falling of the internal vault, the effects of which will be felt at the surface as undulations and tremblings. All these causes combine to make of earthquakes a very complex phenomenon.

We might expect to find a species of tide-movement in the lava of active volcanoes, but data on this point are lacking. The only fact we have bearing upon it is derived from the observations of Scacchi and Palmieri during the eruption of Vesuvius in May, 1855, who noticed an increase in the flow of the lava twice daily at intervals of about twelve hours' duration, and with a little less than an hour's retardation from one day to the next, as observed in the ocean-tides. The eruption commenced on the 1st of May, and the periodic swelling of the lava-stream was observed from the 5th to the 19th. Such observations could easily be made in the island of Hawaii, on the borders of the lava-lake of Kilauea.

It must not be forgotten that these subterranean tides do not by any means demonstrate the liquidity of the nucleus, but simply the existence of a liquid mass of a certain depth. It will be shown how astronomic phenomena furnish data for the solution of this question, but we will first glance at some purely physical considerations that have been advanced in elucidation of the matter.

Mr. James Thompson was the first to point out that compression would have the effect of lowering the point of fusion, and consequently of retarding the congelation of those liquids that expand in solidifying. This has been shown to be the case with water, and it would probably be found to be the same with iron. On the other hand, in the case of the far more numerous substances that contract in solidifying, compression facilitates congelation by cooling the mass. It ought, therefore, to raise the point of fusion, and this is known to occur with many bodies. Thus the melting-point of sulphur, which shrinks materially in solidifying, is raised from 107° to 140° under a pressure of eight hundred atmospheres. Now, according to the experiments of Bischof, the greater part of the rocks expand by fusion and contract in solidifying. Granite, the schists, and trachyte shrink about one fifth in solidifying. This tends to confirm the supposition, says Sir W. Thomson, that the earth's nucleus has long been solidified.

Let us conceive the earth as primarily wholly liquid. There would be established in the mass an equilibrium of temperature corresponding to a given pressure. As the mass cooled, solidification would commence, either on the surface or at the center. The question is a very complex one and can not be fully solved without a better knowledge than we have of the properties of the liquid under consideration. But assuming that solidification commences at the surface, a thin skin will first be formed, and this being by the hypothesis heavier than the liquid it covers—since its volume shrinks in solidifying—it follows that it must be broken up and the fragments be carried to the bottom or center, forming there a solid nucleus. Thus, in any event, solidification will occur at the center, and, when the entire mass has acquired a temperature near the point of solidification, a solid carapace will gradually cover the surface, beneath which here and there masses of liquid will still exist.

This argument, however, is open to question in several respects. M. Mallet's experiments, for instance, with the scoriæ of smelting-furnaces, show that certain silicates contract only six per cent. The celebrated engineer, Werner Siemens, cites, as opposed to Sir W. Thomson's theory, the results of his experiments at the glass-works of his brother, Fr. Siemens, at Dresden. When the melted vitreous mass commenced to cool, contraction was at first very rapid, then more gradual as it attained a pasty consistency, and at the time of solidification it even seemed to expand slightly. From this M. Siemens concludes that the contraction resulting from the solidification of the fused silicates occurs during the change from the liquid to the pasty state; and, by Sir W. Thomson's reasoning, it would seem all the more probable that the central portions of the globe have already attained a pasty consistency.*

On the supposition that the solid crust has but a slight thickness, many phenomena are explained, notably the ascent of lava in volcanic vents, which might thus be due to the hydrostatic pressure caused by the weight of masses of rock. This same cause may even have contributed to the elevation of mountains, by forcing the lighter solid masses above the level of a sea of heavier lava. Again, the slow changes of level of the land, as seen in the changes in certain coast-lines, indicate a mobility of the solid crust, which would naturally experience oscillations in consequence of a secular displacement of its center of gravity, and this displacement may result from modifications of the exterior surface by the action of water, and of the inner surface by the action of lava. Indeed, do not earthquakes—whose cause may be found as well in the falling of masses of rock, or the action of subterranean waters, as in purely volcanic phenomena—constantly show that great changes are occurring in the depths of the ground?

Sir George Airy has lent the weight of his great authority to the hypothesis of a liquid nucleus, in his recent interesting address at Cockermouth, before an audience of miners and others. The illustrious astronomer royal holds the opinion that the earth's crust is formed of more or less compact rocks that float on a mass of fluid or semifluid lava. The heaviest of the rocks form the ocean-beds; lighter ones the continents; and the mountains are composed of the portions that project the farthest into the lava, in exactly the same way that large ships draw more water than small ones. It follows from this that beneath the mountains a considerable volume of relatively dense lava has been displaced by lighter masses, which would account for the slight effect produced by certain ranges—the Himalayas, for example—on the plummet.

Again, it is on the hypothesis of an internal fire that such theories of the elevation of mountains as that of M. Elie de Beaumont are founded. The earth's crust in cooling undergoes a contraction, causing ruptures on the arcs of great circles; the lava, as it is compressed by the contracting solidified crust, is forced through these fissures,

* "Physikalisch-mechanische Betrachtungen" ("Monatsbericht der Acad. der Wiss. zu Berlin," 1878).

folding back and elevating the edges, and forming, as it solidifies, long ridges which constitute the mountain-chains. The waters, displaced from their old beds, seek new basins, and, as a state of calm is reëstablished, they deposit the matter with which they become charged during the period of disturbance; and it is thus that sedimentary deposits, spreading over the more ancient disruptions, are formed. The existing configuration of the surface would thus be the resultant of a series of elevations separated by long intervals of time. The chronology of these occurrences M. de Beaumont has endeavored to establish by the aid of geometric laws, by virtue of which chains of contemporary formation assume a parallel direction. This theory of mountain upheavals has its weak features, especially that relating to the synchronism of its formations. It has been vigorously combated by the Sir Charles Lyell school, which attributes all the changes of the earth's surface to the slow action of forces that are still in operation about us. In considering the prodigious effects of volcanic eruptions and earthquakes, the secular oscillations of the ground, the changes of the earth's surface even in our day by the action of the sea and of rivers, the partisans of uniformity in geological changes reject the theory of cataclysms, as held by the opposite school. Still, it can not be denied that the earth has grown old, and that its energy must have diminished. On this point Sir W. Thomson makes a judicious remark: "It might be surprising but strictly admissible to assert that volcanic activity as a whole has never been more intense than at the present time. But it is not less certain that the earth contains to-day a smaller store of volcanic energy than it did a thousand years ago, as a ship of war, after a sharp engagement for five hours without replenishing its ammunition, contains less powder in its magazine than before the combat." Again, M. Charles Sainte-Claire Deville, in his lectures at the College of France, cited, in opposition to the uniformity theory, some considerations borrowed from an article of M. J. Bertrand's, on similitude in mechanism, from which it appears impossible, in accounting for a displacement of a given magnitude, to compensate for a deficit in energy by an indefinite extension of the time employed.

There is thus no lack of argument drawn from geognosy to sustain the hypothesis that changes in the earth are attributable to the mobility of the liquid nucleus; but we now pass to an examination of those furnished by astronomy.

Emanuel Swedenborg left behind him as a souvenir only a theosophy and a thaumaturgy; he was, however, a distinguished engineer, and before becoming the leader of a sect of visionaries, as the assessor of the Stockholm College of Mines published some researches that are not without value. In his great work of 1734 ("Principia Rerum Naturalium"), to which M. Nyren has recently called the attention of the scientific world, is for the first time elaborated a theory of the universe closely resembling the celebrated cosmogonic hypothesis of Laplace.

Swedenborg postulates a solar vortex, from which is gradually detached a ring, by the disruption of which the planetary globes and their satellites are formed.* Twenty years later analogous ideas were held by Immanuel Kant, who, it would seem, merely commented on and developed the views of Thomas Wright.† In this system the planets are formed directly by the condensation of nebulous matter without the intermediate formation of rings. These theories are curious in the light of the history of science. There is also the theory of Buffon, who imagined that a comet, striking the sun, forced from it a stream of matter that agglomerated to form the planets. But Laplace was the first to offer a theory of the origin of the solar system that was founded on rigorously scientific principles, and that conformed to the data of celestial mechanics. That which distinguishes the conceptions of his genius is, that the discoveries since made, far from weakening his hypothesis, seem on the contrary to daily strengthen it.

Laplace conceived all the stars formed by the gradual concentration of a nebulosity diffused in space, which became luminous in proportion as it condensed, under the force of gravitation. The sun itself was at first nebulous, with a brilliant nucleus. Supposing the system endowed with a rotary movement—and this is an unavoidable postulate—the solar atmosphere at first assumed a figure of spheroidal equilibrium, much flattened, and limited in its dimensions by the zone where the centrifugal force counterbalanced the weight. The molecules situated beyond this limit ceased to belong to the atmosphere proper, and revolved freely around the central star as planetary masses. Now, a law of mechanics teaches that in proportion as the cooling contracts the atmosphere and condenses the molecules in the vicinity of the nucleus, the rotation becomes more rapid ; the centrifugal force thereby augmenting, the point where the weight counterbalances it is brought nearer the center, and the particles banished to the outskirts become planets. Contracting little by little, the solar atmosphere became separated from the zone of vapors in the plane of its equator. These abandoned vapors, wrecks of the solar ocean, must first have formed concentric rings circulating around the sun, comparable to the rings of Saturn. These rings would soon break up into several masses, which, speedily conglobulating, assumed a rotary movement in the direction of their revolution around the sun. It is thus that the planets originate, and give birth, in cooling, to the satellites that accompany them. "Hence," says Laplace, "the notable phenomenon of the slight eccentricity of the orbits of the planets and their satellites ; of the slight inclination of these orbits to the plane of the solar equator ; and of the identity of movement, in rotation and revolution, of all these bodies with that of the sun, giving to the hypothesis we offer a high degree

* The chapter is entitled "De chao universali solis et planetarum, deque separatione ejus in planetas et satellites."

† "An Original Theory or New Hypothesis of the Universe." London, 1750.

of verity." This also explains why the duration of the sun's rotation, twenty-five days, is less than that of the revolution of the various planets. And the triple ring of Saturn seems to be an ocular proof of the original extension of the atmosphere of that planet, and of its successive contractions. So many analogous phenomena certainly render Laplace's cosmogonic hypothesis highly probable.

A final confirmation of the theory is supplied by spectrum analysis. The study of the spectra of the nebulæ has demonstrated that, if many of them are merely agglomerations of stars, others are still gaseous bodies—veritable specimens of the primitive chaos, exemplifying perfectly Kant's, W. Herschel's, and Laplace's conception of the beginnings of worlds as they left the Creator's hands. Of the nebulæ two appear to be composed of a central globe with a ring like Saturn's, and in many others it seems possible to discern the gyratory movement by means of which planetary systems are formed.

Of recent investigations that have served to establish the basis and develop the results of Laplace's theory, we must place in the first rank the valuable researches of M. Edouard Roche, on the form of the heavenly bodies, which the author has recently supplemented by an essay on the constitution and origin of the solar system. M. Roche first demonstrates that by virtue of the particular form of the "free surface" bordering the atmosphere—a surface having a projecting ridge at the equator—as the nebula contracts a fluid stratum will slide from the poles toward the equator and be thrown off over the equatorial ridge as through an opening. It is thus that an equatorial zone, independent of the central body, will be formed and become an outer ring.

But the theory shows that *inner* rings will be formed from portions of the mobile matter brought toward the equator from the poles, and it is thus that Saturn's two inner rings would be formed, their radius being less than twice that of the planet. The equatorial extent of the planet's atmosphere being at present equal to 2, there can not have been a ring *thrown off* inside this distance. Laplace's theory, not admitting inner rings, accounts only for the formation of the largest of the three. M. Roche also holds that the moon was formed from an inner ring, and that it was developed in the bosom of the earth's atmosphere, which, withdrawing little by little, left its satellite free.

Every conception that favors Laplace's theory clearly tends to confirm the hypothesis of the earth's original fluidity, but without settling the question of the liquidity of the nucleus at the present time. Let us see to what extent this obscure question has been elucidated.

The equatorial swelling, which changes so slightly the spherical form of the globe, has nevertheless a very appreciable effect on the globe's rotation on its axis. If the earth were an exact sphere and entirely homogeneous, or if it were composed of homogeneous concentric spheres, the sun's attraction would have no effect on the movement of rotation; the axis of the earth would always remain parallel to itself—i. e., always point to the same place in the heavens; but the sun's action on the equatorial protuberance gradually effects a change of direction in the earth's axis, and the moon produces an analogous effect. These perturbations constitute the phenomena of the precession of the equinoxes and nutation, by virtue of which the celestial pole is continually displaced among the stars.

It is from such considerations as these that Mr. Hopkins has drawn a serious argument against the fluidity of the earth's interior.* In considering the effect of the sun's and moon's action on the equatorial swelling, says Mr. Hopkins, we look upon the earth as a solid body, with all of its parts joined together, which ought to experience in its entirety the effects of these perturbing causes. But, if the earth is a liquid mass covered by a solid shell, these effects will be exerted only on the solid portion, which will in a manner slide on the liquid nucleus. As the perturbing forces will thus act on so small a portion of the globe, the effect on the rotary movement of the crust ought to be much greater than if the earth were viewed as a solid mass, and these forces will be the more intense in proportion as the crust is thin. In order to reconcile the possible effect of luni-solar action on the equatorial protuberance with the known amount of precession and nutation, Mr. Hopkins calculates the requisite thickness of the crust at not less than thirteen hundred to sixteen hundred kilometres, or from a fifth to a quarter of the earth's radius.

Mr. Hopkins's calculations were revised twenty years later by Sir W. Thomson in his "Memoir on the Rigidity of the Earth," † in which this illustrious physicist gives to Mr. Hopkins's views all the weight of his authority. "Whatever objection may be made to the mathematical portion of Mr. Hopkins's work," he says, "I can see no force in the reasoning employed to refute his conclusions, and I am happy to see my opinion in the matter confirmed by such an eminent authority as Archdeacon Pratt. It has, indeed, always seemed to me that Mr. Hopkins might have carried his argument further, and concluded that no completely liquid mass, approximating to a spheroid six thousand miles in diameter, can exist in the interior of the earth without being accompanied by a very different rate of precession and nutation from that which actually exists."

These arguments grew in favor with geologists, and the hypothesis of a liquid nucleus was gradually relegated to the limbo of superannuated prejudices, when the lamented M. Delaunay undertook to demolish the principal argument, and declared that in his opinion Mr. Hopkins's reasoning had no real foundation.‡ "To make clear our idea," said M. Delaunay, "let us take a glass globe filled with water.

* "Philosophical Transactions of the Royal Society," London, 1839–1842.

† Ibid., 1863.

‡ "Comptes rendus de l'Académie des Sciences," July, 1868.

If it is admitted that this liquid is endowed with an absolute fluidity, it is evident that, by giving the globe a brisk rotary movement on a vertical axis, it will turn without carrying the liquid around with it. This may be readily verified by giving it a more or less rapid movement of rotation. Light substances suspended in the water will appear to remain still, despite the ball's rotation. But will this always be the case, whatever the speed of rotation? If the globe were very slowly revolved, would the liquid still be unaffected by the movement of its envelope? In conceding the perfect fluidity of the liquid, its *viscosity* has been lost sight of. Now, this viscosity, though slight, is not *nil;* hence, if the rotation be sufficiently slow, the liquid will be carried around with the glass globe, the whole revolving as one piece, or solid ball." This rotation of the liquid under the conditions described has been demonstrated by M. Champagneur in a series of experiments undertaken, by request of M. Delaunay, in the laboratory of the Sorbonne.

Applying this reasoning to the earth, we will assume that it is composed of a liquid mass covered by a solid pellicle. It is first of all evident that, if we set aside the perturbations caused by the equatorial enlargement, the entire mass will turn as one piece on its axis; if any difference whatever could exist between the rate of the envelope's rotation and that of the nucleus, friction will speedily annul it. The perturbing influence of precession and nutation imparts to the solid envelope's proper movement of rotation an extremely slight acceleration. The question is, Does the internal liquid participate in this additional movement, or is the crust only affected by it? "As for me," says M. Delaunay, "there is no room for the slightest doubt. The acceleration due to the causes indicated is so slight that the fluid of the interior must follow the inclosing shell exactly as though the whole were a solid mass. So enormous is the pressure to which the various parts of the liquid mass are subjected that we can form no idea of its effect on the viscosity of the fluid in question. But if that fluid is in the condition of those we are familiar with, what we have described would occur." M. Delaunay concludes by stating that, in his opinion, the phenomena of precession and nutation can furnish no data concerning the greater or less thickness of the earth's crust.

Sir William Thomson again considers the question, and from a new point of view. In theoretically determining the height of the tides, the water only is supposed to yield to the luni-solar attraction—the solid shell of the earth being unaffected by it. Now, it is evident that even an entirely solid sphere will be slightly changed in form by these forces, and that the change will be still greater in a partially liquid sphere. We will first suppose that the entire mass of the globe yields to the attracting forces as readily as if it were liquid. In this case sea and solid land will be raised alike, and, the surface of the sea always being at the same distance from the bottom, no tides will be seen. Granting that the average rigidity of the globe's mass is comparable to that of glass, we see that it must undergo a change of form equal to 0·6 of that which it would experience if it were liquid; and, deducting this elevation from the rise of the oceanic sheet, the height of the tide is not more than 0·4 of what it would be on a perfectly rigid ball.

Assuming the rigidity of the terrestrial mass to be that of steel, Sir W. Thomson estimates that it would still undergo a change from sphericity equal to one third of that of a liquid sphere, and the apparent height of the tides is thus found to be reduced to two thirds of that which would be produced on an absolutely rigid ball. Sir W. Thomson, while fully recognizing the uncertainty in which this question of the height of the tides rests, still deems it inadmissible that the actual height is only 0·4 of the theoretical height on the hypothesis of a globe of absolute rigidity. He accordingly concludes that our globe possesses a rigidity greater than that of glass, and perhaps than that of steel. Regarding the influence on the phenomena of precession and nutation due to the globe's elasticity, the deductions from the hypothesis of absolute rigidity accord with observation, and this would tend to confirm the conclusions drawn from the observations of the tides. Even if the variability of form tends directly to diminish the effect called precession, there still exists an indirect effect of this variation which tends to augment it, so that possibly these two contrary effects may nearly counterbalance each other.

Everything considered, it is not impossible to reconcile these conclusions with the existence of an intense heat in the central portions of the globe. It must not be forgotten that these central beds are subjected to a pressure increasing in intensity toward the center. By M. Roche's law of densities, we find that the pressure at the center exceeds 3,000,000 kilogrammes per square centimetre (3,000,000 atmospheres). We can form no idea of the physical condition of substances exposed to such a pressure. Experiments on the resistance of various substances have shown that small cubes of granite crumble under a weight of 700 atmospheres; basalt and porphyry under 2,000 and 2,500 atmospheres respectively. Under such pressure the rocks disintegrate and are pulverized. Copper, steel, and cast iron resist twice or thrice this pressure, but what will be the state of the metals under a pressure one hundred or one thousand times greater? What is the action of molecular forces, in solids or liquids, subjected to a pressure of several millions of atmospheres, and, at the same time, to a temperature of some thousand degrees? What *is* the solid or the liquid state under these conditions? Data on this point are absolutely lacking, and anything advanced thereon must be purely hypothetical. "We may compare mathematics," Professor Huxley aptly says, "to a mill of admirable construction, capable of grinding to any degree of fineness, but what comes from it depends upon what has been put into it, and, as the most perfect mill conceivable will not produce flour if only pea-pods are put into it, pages on pages of formulæ will not give an exact result from inexact data."

ON THE METHOD OF ZADIG:

RETROSPECTIVE PROPHECY AS A FUNCTION OF SCIENCE.

BY PROFESSOR T. H. HUXLEY.

"Une marque plus sûre que toutes celles de Zadig."—CUVIER.*

IT is a usual and a commendable practice to preface the discussion of the views of a philosophic thinker by some account of the man and of the circumstances which shaped his life and colored his way of looking at things; but, though Zadig is cited in one of the most important chapters of Cuvier's greatest work, little is known about him, and that little might perhaps be better authenticated than it is.

It is said that he lived at Babylon in the time of King Moabdar; but the name of Moabdar does not appear in the list of Babylonian sovereigns brought to light by the patience and the industry of the decipherers of cuneiform inscriptions in these later years; nor indeed am I aware that there is any other authority for his existence than that of the biographer of Zadig, one Arouet de Voltaire, among whose most conspicuous merits strict historical accuracy is perhaps hardly to be reckoned.

Happily Zadig is in the position of a great many other philosophers. What he was like when he was in the flesh, indeed whether he existed at all, are matters of no great consequence. What we care about in a light is that it shows the way, not whether it is lamp or candle, tallow or wax. Our only real interest in Zadig lies in the conceptions of which he is the putative father; and his biographer has stated these with so much clearness and vivacious illustration that we need hardly feel a pang, even if critical research should prove King Moabdar and all the rest of the story to be unhistorical, and reduce Zadig himself to the shadowy condition of a solar myth.

Voltaire tells us that, disenchanted with life by sundry domestic misadventures, Zadig withdrew from the turmoil of Babylon to a secluded retreat on the banks of the Euphrates, where he beguiled his solitude by the study of nature. The manifold wonders of the world of life had a peculiar attraction for the lonely student; incessant and patient observation of the plants and animals about him sharpened his naturally good powers of observation and of reasoning; until, at

* "Discours sur les Révolutions de la Surface du Globe," "*Recherches sur les Ossemens fossiles*," ed. iv, t. i, p. 185.

length, he acquired a sagacity which enabled him to perceive endless minute differences among objects which, to the untutored eye, appeared absolutely alike.

It might have been expected that this enlargement of the powers of the mind and of its store of natural knowledge could tend to nothing but the increase of a man's own welfare and the good of his fellow men. But Zadig was fated to experience the vanity of such expectations.

One day, walking near a little wood, he saw, hastening that way, one of the queen's chief eunuchs, followed by a troop of officials, who appeared to be in the greatest anxiety, running hither and thither like men distraught, in search of some lost treasure.

"Young man," cried the eunuch, "have you seen the queen's dog?" Zadig answered modestly, "A bitch, I think, not a dog." "Quite right," replied the enuuch; and Zadig continued: "A very small spaniel who has lately had puppies; she limps with the left foreleg, and has very long ears." "Ah! you have seen her, then?" said the breathless eunuch. "No," answered Zadig, "I have not seen her; and I really was not aware that the queen possessed a spaniel."

By an odd coincidence, at the very same time, the handsomest horse in the king's stables broke away from his groom in the Babylonian plains. The grand huntsman and all his staff were seeking the horse with as much anxiety as the eunuch and his people the spaniel; and the grand huntsman asked Zadig if he had not seen the king's horse go that way.

"A first-rate galloper, small-hoofed, five feet high; tail three feet and a half long; cheek-pieces of the bit of twenty-three carat gold; shoes silver?" said Zadig.

"Which way did he go? Where is he?" cried the grand huntsman.

"I have not seen anything of the horse, and I never heard of him before," replied Zadig.

The grand huntsman and the chief eunuch made sure that Zadig had stòlen both the king's horse and the queen's spaniel, so they haled him before the high court of Desterham, which at once condemned him to the knout and transportation for life to Siberia. But the sentence was hardly pronounced when the lost horse and spaniel were found. So the judges were under the painful necessity of reconsidering their decision; but they fined Zadig four hundred ounces of gold for saying that he had seen that which he had not seen.

The first thing was to pay the fine; afterward Zadig was permitted to open his defense to the court, which he did in the following terms:

"Stars of justice, abysses of knowledge, mirrors of truth, whose gravity is as that of lead, whose inflexibility is as that of iron, who rival the diamond in clearness, and possess no little affinity with gold; since I am permitted to address your august assembly, I swear by Ormuzd that I have never seen the respectable lady dog of the queen, nor beheld the sacrosanct horse of the King of kings.

"This is what happened: I was taking a walk toward the little wood near which I subsequently had the honor to meet the venerable chief eunuch and the most illustrious grand huntsman. I noticed the track of an animal in the sand, and it was easy to see that it was that of a small dog. Long faint streaks upon the little elevations of sand between the foot-marks convinced me that it was a she-dog, with pendent dugs—showing that she must have had puppies not many days since. Other scrapings of the sand, which always lay close to the marks of the fore-paws, indicated that she had very long ears; and, as the imprint of one foot was always fainter than those of the other three, I judged that the lady dog of our august queen was, if I may venture to say so, a little lame.

"With respect to the horse of the King of kings, permit me to observe that, wandering through the paths which traverse the wood, I noticed the marks of horseshoes. They were all equidistant. 'Ah!' said I, 'this is a famous galloper.' In a narrow alley, only seven feet wide, the dust upon the trunks of the trees was a little disturbed at three feet and a half from the middle of the path. 'This horse,' said I to myself, 'had a tail three feet and a half long, and, lashing it from one side to the other, he has swept away the dust.' Branches of trees met overhead at the height of five feet, and under them I saw newly fallen leaves; so I knew the horse had brushed some of the branches and was therefore five feet high. As to his bit, it must have been made of twenty-three carat gold, for he had rubbed it against a stone, which turned out to be a touchstone, with the properties of which I am familiar by experiment. Lastly, by the marks which his shoes left upon pebbles of another kind, I was led to think that his shoes were of fine silver."

All the judges admired Zadig's profound and subtile discernment; and the fame of it reached even the king and the queen. From the anterooms to the presence-chamber, Zadig's name was in everybody's mouth; and, although many of the magi were of the opinion that he ought to be burned as a sorcerer, the king commanded that the four hundred ounces of gold which he had been fined should be restored to him. So the officers of the court went in state with the four hundred ounces; only they retained three hundred and ninety-eight for legal expenses, and their servants expected fees.

Those who are interested in learning more of the fateful history of Zadig must turn to the original; we are dealing with him only as a philosopher, and this brief excerpt suffices for the exemplification of the nature of his conclusions and of the method by which he arrived at them.

These conclusions may be said to be of the nature of retrospective prophecies; though it is perhaps a little hazardous to employ phraseology which perilously suggests a contradiction in terms—the word "prophecy" being so constantly, in ordinary use, restricted to "foretelling." Strictly, however, the term prophecy as much applies to outspeaking as to foretelling; and, even in the restricted sense of "divination," it is obvious that the essence of the prophetic operation does not lie in its backward or forward relation to the course of time, but in the fact that it is the apprehension of that which lies out of the sphere of immediate knowledge; the seeing of that which to the natural sense of the seer is invisible.

The foreteller asserts that, at some future time, a properly situated observer will witness certain events; the clairvoyant declares that, at this present time, certain things are to be witnessed a thousand miles away; the retrospective prophet (would that there were such a word as "backteller"!) affirms that, so many hours or years ago, such and such things were to be seen. In all these cases it is only the relation to time which alters—the process of divination beyond the limits of possible direct knowledge remains the same.

No doubt it was their instinctive recognition of the analogy between Zadig's results and those obtained by authorized inspiration which inspired the Babylonian magi with the desire to burn the philosopher. Zadig admitted that he had never either seen or heard of the horse of the king or of the spaniel of the queen; and yet he ventured to assert in the most positive manner that animals answering to their description did actually exist, and ran about the plains of Babylon. If his method was good for the divination of the course of events ten hours old, why should it not be good for those of ten years or ten centuries past; nay, might it not extend to ten thousand years, and justify the impious in meddling with the traditions of Oannes and the fish, and all the sacred foundations of Babylonian cosmogony?

But this was not the worst. There was another consideration which obviously dictated to the more thoughtful of the magi the propriety of burning Zadig out of hand. His defense was worse than his offense. It showed that his mode of divination was fraught with danger to magianism in general. Swollen with the pride of human reason, he had ignored the established canons of magian lore; and, trusting to what after all was mere carnal common sense, he professed to lead men to a deeper insight into nature than magian wisdom, with all its lofty antagonism to everything common, had ever reached. What, in fact, lay at the foundation of all Zadig's arguments but the coarse, commonplace assumption upon which every act of our daily lives is based, that we may conclude from an effect to the preëxistence of a cause competent to produce that effect?

The tracks were exactly like those which dogs and horses leave; therefore they were the effects of such animals as causes. The marks at the sides of the fore-prints of the dog-track were exactly such as would be produced by long, trailing ears; therefore the dog's long ears were the causes of these marks—and so on. Nothing can be more hopelessly vulgar, more unlike the majestic development of a system of grandly unintelligible conclusions from sublimely inconceivable premises, such as delights the magian heart. In fact, Zadig's method was nothing but the method of all mankind. Retrospective prophecies, far more astonishing for their minute accuracy than those of Zadig, are familiar to those who have watched the daily life of nomadic people.

From freshly broken twigs, crushed leaves, disturbed pebbles, and imprints hardly discernible by the untrained eye, such graduates in the University of Nature will divine, not only the fact that a party has passed that way, but its strength, its composition, the course it took, and the number of hours or days which have elapsed since it passed. But they are able to do this because, like Zadig, they perceive endless minute differences where untrained eyes discern nothing; and because the unconscious logic of common sense compels them to account for these effects by the causes which they know to be competent to produce them.

And such mere methodized savagery was to discover the hidden things of nature better than *a priori* deductions from the nature of Ormuzd—perhaps to give a history of the past, in which Oannes would be altogether ignored! Decidedly it were better to burn this man at once.

If instinct, or an unwonted use of reason, led Moabdar's magi to this conclusion two or three thousand years ago, all that can be said is that subsequent history has fully justified them. For the rigorous application of Zadig's logic to the results of accurate and long-continued observation has founded all those sciences which have been termed historical or palætiological, because they are retrospectively prophetic and strive toward the reconstruction in human imagination of events which have vanished and ceased to be.

History, in the ordinary acceptation of the word, is based upon the interpretation of documentary evidence; and documents would have no evidential value unless historians were justified in their assumption that they have come into existence by the operation of causes similar to those of which documents are, in our present experience, the effects. If a written history can be produced otherwise than by human agency, or if the man who wrote a given document was actuated by other than ordinary human motives, such documents are of no more evidential value than so many arabesques.

Archæology, which takes up the thread of history beyond the point at which documentary evidence fails us, could have no existence, except for our well-grounded confidence that monuments and works of art, or artifice, have never been produced by causes different in kind from those to which they now owe their origin. And geology, which traces back the course of history beyond the limits of archæology, could tell us nothing except for the assumption that, millions of years ago, water, heat, gravitation, friction, animal and vegetable life, caused effects of the same kind as they do now. Nay, even physical astronomy, in so far as it takes us back to the uttermost point of time which palætiological science can reach, is founded upon the same assumption. If the law of gravitation ever failed to be true, even to the smallest extent, for that period, the calculations of the astronomer have no application.

The power of prediction, of prospective prophecy, is that which is commonly regarded as the great prerogative of physical science. And truly it is a wonderful fact that one can go into a shop and buy for small price a book, the "Nautical Almanac," which will foretell the exact position to be occupied by one of Jupiter's moons six months hence; nay, more, that, if it were worth while, the Astronomer Royal could furnish us with as infallible a prediction applicable to 1980 or 2980.

But astronomy is not less remarkable for its power of retrospective prophecy.

Thales, oldest of Greek philosophers, the dates of whose birth and death are uncertain, but who flourished about 600 B. C., is said to have foretold an eclipse of the sun which took place in his time during a battle between the Medes and the Lydians. Sir George Airy has written a very learned and interesting memoir * in which he proves that such an eclipse was visible in Lydia on the afternoon of the 28th of May, in the year 585 B. C.

No one doubts that, on the day and at the hour mentioned by the Astronomer Royal, the people of Asia Minor saw the face of the sun totally obscured. But, though we implicitly believe this retrospective prophecy, it is incapable of verification. It is impossible even to conceive any means of ascertaining directly whether the eclipse of Thales happened or not. All that can be said is, that the prospective prophecies of the astronomer are always verified; and that, inasmuch as his retrospective prophecies are the result of following backward the very same method as that which invariably leads to verified results when it is worked forward, there is as much reason for placing full confidence in the one as in the other. Retrospective prophecy is therefore a legitimate function of astronomical science; and if it is legitimate for one science it is legitimate for all; the fundamental axiom on which it rests, the constancy of the order of nature, being the common foundation of all scientific thought. Indeed, if there can be grades in legitimacy, certain branches of science have the advantage over astronomy, in so far as their retrospective prophecies are not only susceptible of verification, but are sometimes strikingly verified.

Such a science exists in that application of the principles of biology to the interpretation of the animal and vegetable remains imbedded in the rocks which compose the surface of the globe, which is called paleontology.

At no very distant time, the question whether these so-called "fossils" were really the remains of animals and plants was hotly disputed. Very learned persons maintained that they were nothing of the kind, but a sort of concretion or crystallization which had taken place within the stone in which they are found; and which simulated the forms of animal and vegetable life, just as frost on a window-pane imitates vegetation. At the present day it would probably be impossible to find any sane advocate of this opinion; and the fact is rather surprising that among the people from whom the circle-squarers, perpetual-motioners, flat-earth men, and the like, are recruited, to say

* "On the Eclipses of Agathocles, Thales, and Xerxes," "Philosophical Transactions," vol. cxliii.

nothing of table-turners and spirit-rappers, somebody has not perceived the easy avenue to nonsensical notoriety open to any one who will take up the good old doctrine that fossils are all *lusus naturæ.*

The position would be impregnable, inasmuch as it is quite impossible to prove the contrary. If a man choose to maintain that a fossil oyster-shell, in spite of its correspondence, down to every minutest particular, with that of an oyster fresh taken out of the sea, was never tenanted by a living oyster, but is a mineral concretion, there is no demonstrating his error. All that can be done is to show him that, by a parity of reasoning, he is bound to admit that a heap of oyster-shells outside a fishmonger's door may also be "sports of Nature," and that a mutton-bone in a dust-bin may have had the like origin. And when you can not prove that people are wrong, but only that they are absurd, the best course is to let them alone.

The whole fabric of paleontology, in fact, falls to the ground unless we admit the validity of Zadig's great principle, that like effects imply like causes; and that the process of reasoning from a shell, or a tooth, or a bone, to the nature of the animal to which it belonged, rests absolutely on the assumption that the likeness of this shell, or tooth, or bone to that of some animal with which we are already acquainted, is such that we are justified in inferring a corresponding degree of likeness in the rest of the two organisms. It is on this very simple principle, and not upon imaginary laws of physiological correlation, about which, in most cases, we know nothing whatever, that the so-called restorations of the paleontologist are based.

Abundant illustrations of this truth will occur to every one who is familiar with paleontology; none is more suitable than the case of the so-called *Belemnites.* In the early days of the study of fossils, this name was given to certain elongated stony bodies, ending at one extremity in a conical point, and truncated at the other, which were commonly reputed to be thunderbolts, and as such to have descended from the sky. They are common enough in some parts of England; and, in the condition in which they are ordinarily found, it might be difficult to give satisfactory reasons for denying them to be merely mineral bodies.

They appear, in fact, to consist of nothing but concentric layers of carbonate of lime, disposed in subcrystalline fibers, or prisms, perpendicular to the layers. Among a great number of specimens of these Belemnites, however, it was soon observed that some showed a conical cavity at the blunt end; and, in still better preserved specimens, this cavity appeared to be divided into chambers by delicate, saucer-shaped partitions, situated at regular intervals one above the other. Now, there is no mineral body which presents any structure comparable to this, and the conclusion suggested itself that the Belemnites must be the effects of causes other than those which are at work in inorganic nature. On close examination, the saucer-shaped partitions were proved to be all perforated at one point, and, the perforations being situated exactly in the same line, the chambers were seen to be traversed by a canal or *siphuncle*, which thus connected the smallest or apical chamber with the largest. There is nothing like this in the vegetable world; but an exactly corresponding structure is met with in the shells of two kinds of existing animals, the pearly *Nautilus* and the *Spirula*, and only in them. These animals belong to the same division—the *Cephalopoda*—as the cuttle-fish, the squid, and the octopus. But they are the only existing members of the group which possess chambered, siphunculated shells; and it is utterly impossible to trace any physiological connection between the very peculiar structural characters of a cephalopod and the presence of a chambered shell. In fact, the squid has, instead of any such shell, a horny "pen," the cuttle-fish has the so-called "cuttle-bone," and the octopus has no shell at all, or a mere rudiment of one.

Nevertheless, seeing that there is nothing in nature at all like the chambered shell of the Belemnite, except the shells of the *Nautilus* and of the *Spirula*, it was legitimate to prophesy that the animal from which the fossil proceeded must have belonged to the group of the *Cephalopoda*. *Nautilus* and *Spirula* are both very rare animals, but the progress of investigation brought to light the singular fact that, though each has the characteristic cephalopodous organization, it is very different from the other. The shell of *Nautilus* is external, that of *Spirula* internal; *Nautilus* has four gills, *Spirula* two; *Nautilus* has multitudinous tentacles, *Spirula* has only ten arms beset with horny rimmed suckers; *Spirula*, like the squids and cuttle-fishes, which it closely resembles, has a bag of ink which it squirts out to cover its retreat when alarmed; *Nautilus* has none.

No amount of physiological reasoning could enable any one to say whether the animal which fabricated the Belemnite was more like *Nautilus*, or more like *Spirula*. But the accidental discovery of Belemnites in due connection with black elongated masses which were certainly fossilized ink-bags, inasmuch as the ink could be ground up and used for painting as well as if it were recent sepia, settled the question; and it became perfectly safe to prophesy that the creature which fabricated the Belemnite was a two-gilled cephalopod with suckers on its arms, and with all the other essential features of our living squids, cuttle-fishes, and *Spirulæ*. The paleontologist was, by this time, able to speak as confidently about the animal of the Belemnite as Zadig was respecting the queen's spaniel. He could give a very fair description of its external appearance, and even enter pretty fully into the details of its internal organization, and yet could declare that neither he, nor any one else, had ever seen one. And, as the queen's spaniel was found, so happily has the animal of the Belemnite; a few exceptionally preserved specimens having been discovered which completely verify the retrospective prophecy of those who interpreted the facts of the case by due application of the method of Zadig.

These Belemnites flourished in prodigious abundance in the seas of the mesozoic or secondary age of the world's geological history; but no trace of them has been found in any of the tertiary deposits, and they appear to have died out toward the close of the mesozoic epoch. The method of Zadig, therefore, applies in full force to the events of a period which is immeasurably remote, which long preceded the origin of the most conspicuous mountain masses of the present world and the deposition, at the bottom of the ocean, of the rocks which form the greater part of the soil of our present continents. The Euphrates itself, at the mouth of which Oannes landed, is a thing of yesterday compared with a Belemnite; and even the liberal chronology of magian cosmogony fixes the beginning of the world only at a time when other applications of Zadig's method afford convincing evidence that, could we have been there to see, things would have looked very much as they do now. Truly the magi were wise in their generation; they foresaw rightly that this pestilent application of the principles of common sense inaugurated by Zadig would be their ruin.

But it may be said that the method of Zadig, which is simple reasoning from analogy, does not account for the most striking feats of modern paleontology—the reconstruction of entire animals from a tooth or perhaps a fragment of a bone; and it may be justly urged that Cuvier, the great master of this kind of investigation, gave a very different account of the process which yielded such remarkable results.

Cuvier is not the first man of ability who has failed to make his own mental processes clear to himself, and he will not be the last. The matter can be easily tested. Search the eight volumes of the "Recherches sur les Ossemens fossiles" from cover to cover, and no reasoning from physiological necessities—nothing but the application of the method of Zadig pure and simple—will be found.

There is one well-known case which may represent all. It is an excellent illustration of Cuvier's sagacity, and he evidently takes some pride in telling his story about it. A split slab of stone arrived from the quarries of Montmartre, the two halves of which contained the greater part of the skeleton of a small animal. On careful examinations of the characters of the teeth and of the lower jaw, which happened to be exposed, Cuvier assured himself that they presented such a very close resemblance to the corresponding parts in the living opossum that he at once assigned the fossil to that genus.

Now, the opossums are unlike most mammals, in that they possess two bones attached to the fore part of the pelvis, which are commonly called "marsupial bones." The name is a misnomer, originally conferred because it was thought that these bones have something to do with the support of the pouch, or marsupium, with which some, but not all, of the opossums are provided. As a matter of fact, they have nothing to do with the support of the pouch, and they exist as much in those opossums which have no pouches as in those which possess them. In truth, no one knows what the use of these bones may be, nor has any valid theory of their physiological import yet been suggested. And, if we have no knowledge of the physiological importance of the bones themselves, it is obviously absurd to pretend that we are able to give physiological reasons why the presence of these bones is associated with certain peculiarities of the teeth and of the jaws. If any one knows why four molar teeth and an inflected angle of the jaw are almost always found along with marsupial bones, he has not yet communicated that knowledge to the world.

If, however, Zadig was right in concluding from the likeness of the hoof-prints which he observed to a horse's that the creature which made them had a tail like that of a horse, Cuvier, seeing that the teeth and jaw of his fossil were just like those of an opossum, had the same right to conclude that the pelvis would also be like an opossum's; and so strong was his conviction that this retrospective prophecy about an animal which he had never seen before, and which had been dead and buried for millions of years, would be verified, that he went to work upon the slab which contained the pelvis in confident expectation of finding and laying bare the "marsupial bones," to the satisfaction of some persons whom he had invited to witness their disinterment. As he says: "Cette opération se fit en présence de quelques personnes à qui j'en avais annoncé d'avance le résultat, dans l'intention de leur prouver par le fait la justice de nos théories zoologiques; puisque le vrai cachet d'une théorie est sans contredit la faculté qu'elle donne de prévoir les phénomènes."

In the "Ossemens fossiles," Cuvier leaves his paper just as it first appeared in the "Annales du Muséum," as "a curious monument of the force of zoölogical laws and of the use which may be made of them."

Zoölogical laws truly, but not physiological laws. If one sees a live dog's head, it is extremely probable that a dog's tail is not far off, though nobody can say why that sort of head and that sort of tail go together; what physiological connection there is between the two. So in the case of the Montmartre fossil, Cuvier, finding a thorough opossum's head, concluded that the pelvis also would be like an opossum's. But, most assuredly, the most advanced physiologist of the present day could throw no light on the question why these are associated, nor could pretend to affirm that the existence of the one is necessarily connected with that of the other. In fact, had it so happened that the pelvis of the fossil had been originally exposed, while the head lay hidden, the presence of the "marsupial bones," however like they might have been to an opossum's, would by no means have warranted the prediction that the skull would turn out to be that of the opossum.

It might just as well have been like that of some other marsupial ; or even like that of the totally different group of Monotremes, of which the only living representatives are the *Echidna* and the *Ornithorhynchus.*

For all practical purposes, however, the empirical laws of coördination of structures which are embodied in the generalizations of morphology may be confidently trusted, if employed with due caution, to lead to a just interpretation of fossil remains ; or, in other words, we may look for the verification of the retrospective prophecies which are based upon them.

And, if this be the case, the late advances which have been made in paleontological discovery open out a new field for such prophecies. For it has been ascertained with respect to many groups of animals, that, as we trace them back in time, their ancestors gradually cease to exhibit those special modifications which at present characterize the type, and more nearly embody the general plan of the group to which they belong.

Thus, in the well-known case of the horse, the toes which are suppressed in the living horse are found to be more and more complete in the older members of the group, until, at the bottom of the Tertiary series of America, we find an equine animal which has four toes in front and three behind. No remains of the horse-tribe are at present known from any Mesozoic deposit. Yet who can doubt that, whenever a sufficiently extensive series of lacustrine and fluviatile beds of that age becomes known, the lineage which has been traced thus far will be continued by equine quadrupeds with an increasing number of digits, until the horse type merges in the five-toed form toward which these gradations point?

But the argument which holds good for the horse holds good, not only for all mammals, but for the whole animal world. And as the study of the pedigrees or lines of evolution to which at present we have access brings to light, as it assuredly will do, the laws of that process, we shall be able to reason from the facts with which the geological record furnishes us to those which have hitherto remained, and many of which, perhaps, may for ever remain hidden. The same method of reasoning which enables us, when furnished with a fragment of an extinct animal, to prophesy the character which the whole organism exhibited, will, sooner or later, enable us, when we know a few of the later terms of a genealogical series, to predict the nature of the earlier terms.

In no very distant future, the method of Zadig, applied to a greater body of facts than the present generation is fortunate enough to handle, will enable the biologist to reconstruct the scheme of life from its beginning, and to speak as confidently of the character of long extinct living beings, no trace of which has been preserved, as Zadig did of the queen's spaniel and the king's horse. Let us hope that they may be better rewarded for their toil and their sagacity than was the Babylonian philosopher; for perhaps, by that time, the magi also may be reckoned among the members of a forgotten fauna, extinguished in the struggle for existence against their great rival common sense.—*Nineteenth Century.*

THE MEDICINAL LEECH.

By Dr. A. BERGHAUS.

MANY swamps and ponds, which are now considered utterly worthless, might be made sources of great profit by devoting them to the production of a worm which is exceedingly valuable, and the cultivation of which requires no expensive outlay. This worm is the medicinal leech; formerly esteemed of no value, and hated and hunted on account of its bloodthirstiness, it has commanded extremely high prices since its useful qualities have been recognized. Its general appearance is familiar, its internal structure is very wonderful. Its body forms a cylindrical sac, composed of a course of about one hundred rings. The terminal ring of the hinder part is broader and stouter than the others, and serves as a foot. At the front extremity, which is more pointed than the hinder part, are two fine, separated lips, which, when brought together, form a closed ring. Several straight lines run along the back for the whole length of the body, while the belly is of a clearer color and is mottled with irregular dark spots. The body of the leech is so elastic that it can stretch itself out to a length of nearly ten inches, and draw itself up again to within the dimensions of an olive. Within and back of the lips are three thick membranous pads covered with a thin, horny mass bearing several rows of microscopic teeth; they may be described as the jaws. Between the jaws passes the very narrow throat, which can be opened and closed at will by means of a transverse muscle. The animal derives its importance to man from the close aggregation of the movable lips, the narrow throat, and the toothed jaws, for it is enabled by this peculiarity to break through the skin and suck the blood from it. The mechanical operation is as follows: When the lips close in a circle upon the air-tight skin, the jaws are also brought down to it and their saw-like teeth are pressed tight upon the cuticle. The throat having now become fast closed, the head of the worm is drawn back a little, and the lips are thereby given the form of an exhausted cupping-glass, which is divided internally, by the jaws still fastened to the skin, into three distinctly separated parts. The skin is powerfully sucked up into these three divisions of the cupping apparatus till it is torn, and rents are formed corresponding to the three spaces between the jaws, the inner ends of which run into each other and form a larger, still three-parted wound. It follows that the sucking of the leech must be without effect on the hairy parts of the body, where a cupping-glass could not be made air-tight, and this is the case. When the space between the skin and lips, which answers to the interior of the cupping-glass, is filled with blood, the throat is opened, the blood is drawn

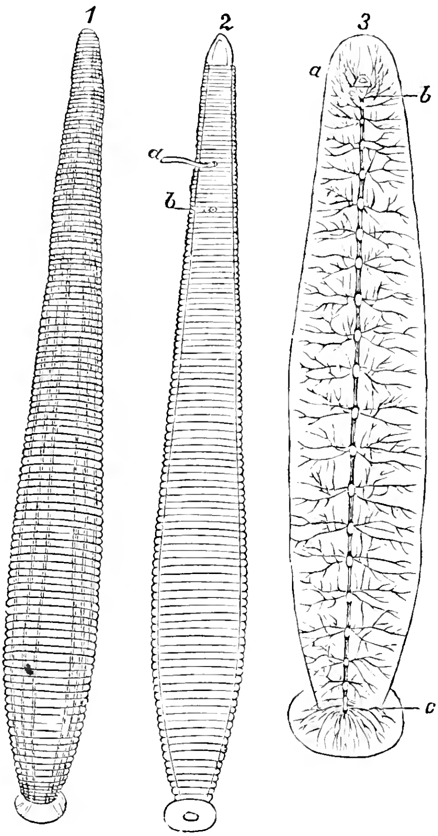


FIG 1.—1. THE MEDICINAL LEECH (*Hirudo medicinalis*) seen from above. 2. The same, under side ; *a b*, sexual organs. 3. The nervous cord with its ramifications : *a*, forward upper part ; *b*, forward lower part ; *c*, posterior nervous node.

by sucking movements of the body into the maw, and the mouth of the worm is filled anew with blood. The long, narrow maw is competent, by means of twenty-six peculiarly formed sacs or valves, which are arranged in two rows, to retain an immense quantity of blood without any of it being driven back by the muscular activity of the body ; and, if a hole is pricked in the body of the leech at the rear end of the maw, all the blood that has been sucked up may be made to flow out. On account of the narrowness of its throat, the leech can not take solid food. Its usual nourishment consists of animal and vegetable infusoria, which it swallows in masses as the whale does herrings; and while the whale spouts out through its nose the water it has swallowed and only retains the herring, the leech exudes the excess of water by means of a peculiar glandular apparatus in its skin, and keeps the infusoria in its maw. It also readily drinks the blood of cold-blooded and warm-

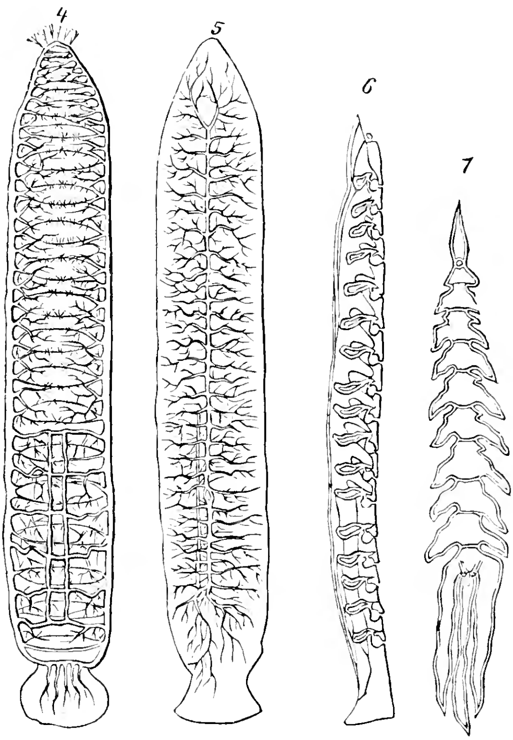


FIG. 2.—4. Arterial system, with the principal vessels (or heart) at the side, and their ramifications. 5. Venous system. 6. The intestinal canal, seen from the side: the round slime-sacs, or breathing-bladders, are situated between the folds of the maw. 7. The intestinal canal, seen from above: the upper part is the throat; the other parts represent the maw and intestines.

blooded animals, and fills itself so greedily with the latter that it can not endure the surfeit, and dies soon afterward. Leeches were formerly abundant in the bogs and ponds of Germany, where, by reason of their great fruitfulness, they increased to millions, and were considered so worthless, even noxious, that the owners of the lands permitted the traveling dealers to fish them out at first for nothing, afterward for a small price. Finally the ponds were cleared of them; the dealers had sold the leeches for an immense profit, and millions on millions of them had been exported from Hamburg to America, and wherever else this costly and irreplaceable medical apparatus was needed, while the land of its production had none. The useful leech is not found in all countries, but its abode is limited to central Europe, Asia Minor, and a small part of the northern coast of Africa. In some of these relatively confined regions it has been exterminated. The demand for it has become very great; France and Germany, for example, use about thirty million, and the exportation from Hamburg alone has been thirty million in a year.* It is not surprising that so important a demand has raised the price of leeches till they have become a very profitable article of trade.

The successful stocking of a pond with leeches is a work requiring considerable care; the animal has many enemies, against which it must be protected, and will not thrive except under specially favorable conditions. The mother-leeches, when planted in the pond, lay their cocoons (which contain the eggs) as in nature, and the young brood is hatched out at the proper time; but this brood, besides protection, requires its natural food, sickens if it does not find it, and can not be fed artificially. The young worms will not thrive in artificial ponds; neither can they be transplanted from other countries and left to themselves without having first undergone a process of acclimatization. The most suitable ponds for acclimatizing leeches should be dug in bog-lands to a depth of about six feet, and should have from about six to ten inches of bog-soil on the bottom. The pond should contain about three feet of water, and should be provided with an inflow of fresh water and be surrounded with a wall two or three feet high. If the leeches are put in the pond in May or June, they will deposit their cocoons toward September in funnel-shaped holes in the peaty bottom; in the course of a few days some ten or fifteen young

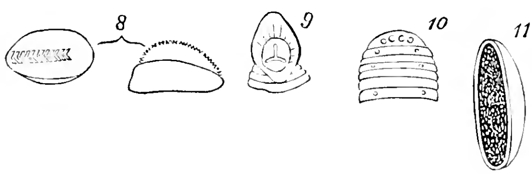


FIG. 3.—8. The jaw, with its saw-like tooth-plates. 9. The head, with its three-parted mouth opening. 10. The upper side of the head, with ten eyes. 11. Section of a cocoon with its eggs.

leeches will come out from the cocoon, and will attach themselves to the old one to suck from it till they are large enough to seek food for themselves. For food, the pond should be furnished with calamus and other reed-like plants; and duck-weed, little fishes, snails and frogs should be put into it. Toward the latter part of the fall the animals

* Although the application of leeches has been diminished in consequence of the adoption of new practices in medicine, which permit bloodletting only in a limited degree, the use of the animal is still considerable, and always will be so. A few years ago, when bloodletting played an important part in sickness, leeches enough could not be got, and it was hard to satisfy the demand in the ordinary way. Five to six million leeches, costing a million and a half of francs, were used in the hospitals of Paris yearly from 1829 to 1836, and 187,000 pounds of blood were drawn annually, or 1,496,000 pounds in the eight years!

should be taken out of the propagating pond and put into a smaller pond with a solid bottom of clear loam or sand, from which they may be taken in the spring to the marshes and bogs, in which, from that time, they will increase quite rapidly.

The question whether leeches can be cultivated on a large scale with profit may be answered decisively in the affirmative by pointing to a few examples in which the business has been carried on successfully. The brothers Béchade hired a large swamp from Baron Pichon, near Bordeaux, as grass-land, for a rent of three hundred francs; after stocking it with leeches they were able to have the rent gradually raised to 25,000 francs without feeling overcharged. Since they began their enterprise, in 1835, leech-culture has risen at Bordeaux to be a source of great profit, involving the application of 5,000 hectares (12,500 acres) of land to the purpose, employing a great many workmen, and representing a capital of several million francs. A landowner in Mecklenburg is said to receive an income of not less than 18,000 marks ($4,284) from his share of the rent of a leech-farm. A physician at Liegingen, in Würtemberg, stocked a marsh of two and a half hectares (six and a quarter acres) with leeches in 1827, and succeeded so well with it that he was able to sell his worms by the hundred-weight.—*Translated from Die Natur.*

RECENT ORIGINAL WORK AT HARVARD.

By J. R. W. HITCHCOCK, A. B.

SOME able and scholarly articles appeared in one of the leading New York dailies during the last winter, comparing Harvard with the principal universities abroad. The writer evidenced his thorough acquaintance with the curriculum and requirements at Harvard, but the original work done there outside the lecture-room was almost completely ignored, and dismissed with hardly a passing mention. This would tend to confirm the impression of the great majority that a university is simply a vast class-room, a place where young men study and recite certain time-honored branches of learning, varying their intellectual labors by feats of physical prowess, and are rewarded at the end of a specified time with mysterious parchment rolls, currently supposed to possess a subtile and awful power. Of the higher aims of a university, and of the distinction between *instructors* and *investigators*, the public at large realize almost nothing.

With a view to showing the inner intellectual activity of a university, I recently visited Harvard studies and laboratories to ascertain what work was being carried on aside from the regular routine of instruction. The spirit that prevails among the gentlemen with whom

I was brought in contact is aptly illustrated by the words of Mill, quoted to me by one of the professors:

"If we were asked for what end, above all others, endowed universities exist, or ought to exist, we should answer: To keep alive philosophy. . . . To educate common minds for the common business of life, a public provision may be useful but is not indispensable."

And after these words followed a strong commendation of a plan for allowing each professor one year in three for independent original research. The wisdom of this becomes evident when we remember that the endowments of the professorships were, with one exception, given for the promotion of teaching. No research fund exists, and aside from the stated work of the university many of the instructors devote a portion of their time to private instruction, which has greatly increased since the success of the recent efforts to have women methodically instructed at Cambridge by Harvard professors. These drains upon the time and energy of the professors render it the more surprising and creditable that so much original research is being constantly carried on in the different departments of the university.

I have only aimed at noting the principal features of the original work carried on, in general, during the year. In some cases it was impossible to dissociate the researches upon which investigators were engaged at the time of my visit from preceding work, but anything like entering into details or giving a modified historical sketch has been utterly impracticable. This will be better appreciated by any one who has seen the catalogue of books and memoirs published by Harvard professors from 1865 to 1875, prepared under the direction of President Eliot in 1875, but unfortunately so printed by the Commissioner of Education as to be valueless for purposes of comparison.

While I acknowledge that my article is necessarily superficial and incomplete, I yet trust it may be found to possess a certain value as giving a view of the highest and yet least known side of the intellectual life of a university.

Professor W. W. Goodwin, at the head of the Greek department, has been recently preparing a new edition of his well-known grammar, and has also been engaged upon several articles on Attic law, Athenian antiquities, and Greek particles for the new edition of Liddell and Scott's lexicon, which is to be republished by Harper & Brothers. An article from the pen of Professor Goodwin recently appeared in Professor Gildersleeve's "Philological Magazine" on a matter of Athenian law. In this connection American scholars will be interested in knowing that Professor Goodwin's "Grammar" and his "Moods and Tenses" have been reprinted in England, and a recent visitor to Oxford spoke to me of seeing these books lying on the tables of Oxford dons and bearing the marks of frequent use.

The amount of Greek required of all students at Harvard has been gradually reduced during the past twenty-five years, until Greek scholars have recognized the fact that, for the department to hold its own, it would be necessary to substitute for the old plan of reading a given amount of Greek, the ability to read Greek readily at sight. To meet this new demand, Professor J. W. White is engaged in preparing a word-book, based on Curtius's Etymology, and not on the more or less untrustworthy etymologies of the lexicon. This book is to contain five or six hundred stems, from which five or six thousand words are to be derived in families, with their Latin and English cognates. This word-book is intended as a direct means of acquiring a vocabulary and facility in reading at sight, and, so far as I know, is entirely a new departure. Professor White is also revising the "First Greek Lessons," which is to be an accompaniment to the new edition of Goodwin's Grammar. He is assisted by the members of a graduate elective—a somewhat novel feature at Cambridge—who are pursuing advanced studies in Greek.

The traditional Latin grammar has become a thing of the past, and, in consequence, college students are daily found ignorant on many points, especially questions of comparative philology, that should have been answered in the schools. In order to furnish a more thorough and satisfactory groundwork for men who are fitting for college, Professor Lane is preparing a Latin grammar which will be based on new and scientific principles. It will be a thoroughly practical book, and, while not dealing directly with questions of comparative philology, will elucidate the important principles of the science.

Professor Greenough, whose name is familiarly known in connection with Allen and Greenough's Latin text-books, is preparing an edition of Vergil.

Since the publication of his "Modern Philosophy" Professor Bowen has been engaged in revising his "Political Economy," a new edition of which will appear in the fall. A volume of his essays is now in press. Within the last year he has written some important papers for the "North American" and "Princeton" Reviews, one of the most remarkable of which is "The Idea of Cause," which appeared in the "Princeton Review" for May, 1879, and has been republished separately.

Professor James is engaged upon a work on psychology, which is to form one of the series of American science text-books. Among his recent writings are articles in "Mind," "The Journal of Speculative Philosophy," "The Popular Science Monthly," and an essay in the "Princeton Review" on the "Sentiment of Rationality."

Perhaps the work that will prove most generally interesting is that upon which Professor Childs is now engaged—a book of English and Scottish ballads, with their derivations and variations. His life-long devotion to this subject, together with his mastery of English literature, will render this book perhaps the most valuable literary production of the year. It is owing to his efforts and researches that the

Harvard library contains the richest collection of literature pertaining to folk and ballad lore in the world.

In connection with original work by students, Professor Hill has introduced a new elective, which consists of oral discussions on given subjects that the students investigate for themselves in the library.

In the department of modern languages, Professor Cook is editing and preparing articles for a French and English lexicon, to be published by Hachette & Co., of Paris. Mr. Sheldon, instructor in German, has recently completed a German grammar.

No course of electives in the university offers a broader and richer field for true culture than those in fine arts, which, though of comparatively recent institution, have been so conducted as to be firmly placed on an enduring footing. Professor Norton, the head of this department, is preparing a book on "Historical Studies of Church-Building in the Middle Ages," which will probably appear within a few months. Assistant Professor Moore, who has recently returned from abroad, brought with him a number of exceedingly instructive copies and drawings made by himself, which serve as an important basis for the art-collection that, it is to be hoped, will be gathered together in connection with this department. The work of the Art Club also deserves mention. This is an association of students, with the coöperation of professors, who meet fortnightly for the discussion of art subjects, and to listen to lectures. The club has recently had two exhibitions, one of Professor Moore's collection, and one of Whistler's etchings, and has printed some valuable contributions to art-literature.

At the time of my visit to Professor Paine he was writing the "Spring Symphony," which has since been produced at a university concert in Sanders's Theatre, and at a Harvard symphony concert in Boston. Among the best known works that Professor Paine has composed of late years are his oratorio "St. Peter," the overture to "As You Like It," brought out by Thomas, the "Centennial Hymn," and a symphony in C minor.

The tendency of the practical mind to judge a man's work by its tangible results leads to a lack of appreciation and a total underrating of the work done by the faithful laborers in the field of *pure* as distinguished from *applied* science. An Edison outdoes the telegraph, or dazzles the world with the electric light, and the gaping crowd who bow before the successful inventor forget that he has simply applied principles and laws discovered long before by silent workers in studies and laboratories, who have toiled on comparatively unknown, amply rewarded by the knowledge that their life-work has added to the world's store of scientific truth. The scientific work of a university, fruitful though it may be in discoveries, is generally under-estimated, because true *savants* the world over feel no interest in turning the results of their work into the practical form of dollars and cents. And so at Harvard the investigations constantly going on in the chemical and physical laboratories, at the Botanic Garden, Agassiz's Museum, and the Observatory, though resulting almost daily in the discovery of new truths, are hardly calculated to awaken popular interest or enthusiasm.

The labors of Professor Benjamin Peirce, the head of the mathematical department, are too extensive to admit of more than a passing mention here. In addition to his private mathematical, physical, and astronomical work, he has entered the field of philosophy in his recent lectures on the connection between religion and science.

In the last publication of the American Academy of Arts and Sciences, in which, by the way, seven of the eight papers are by Harvard investigators, appear the following "Propositions in Cosmical Physics," by Professor Benjamin Peirce:

1. All stellar light emanates from superheated gas. Hence the sun and stars are gaseous bodies.

2. Gaseous bodies, in the process of radiating light and heat, condense and become hotter throughout their mass.

3. It is probable that their surface would become colder if there were not an external supply of heat from the collision of meteors.

4. Large celestial bodies are constantly deriving superficial heat from the collision of meteors, till at length the surface becomes superheated gas, which constitution must finally extend through the mass.

5. Small celestial bodies are constantly cooling till they become invisible solid meteors.

6. The heat of space consists of two parts: first, that of radiation principally from the stars, which is small, except in the immediate vicinity of the stars; the second portion is derived from the velocity with which the meteors strike the planet at which the observation is taken; and this velocity partly depends upon the mass of the star by which the orbit of the planet is defined, and partly upon the mass of the planet itself.

7. If the planets were originally formed by the collision of meteors, it is difficult to account for an initial heat sufficient to liquefy them, and, at the same time, to account for their subsequent cooling without a great change in the number and nature of the meteors; and any such hypothesis seems to invalidate the meteoric theory.

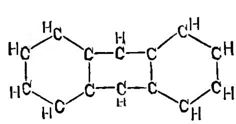
8. If the planets were not originally formed by the collision of meteors, their common direction of rotation becomes difficult of explanation.

Professor J. M. Peirce has recently published a set of "Mathematical Tables," in which the part relating to "Hyperbolic Functions" is entirely original. Other work in this department is represented by Professor Byerly's "Differential Calculus" and Mr. Wheeler's "Elementary Plane and Spherical Trigonometry."

The forbidding granite building called "Boylston Hall" conceals scenes of strange activity. Unwonted odors irritate the inexperienced nose of the visitor, and in the laboratories spectral shapes flit backward and forward behind clouds of vapor, occasionally lit up by lurid flames. These are the students; but in their private laboratories the professors pursue their own researches. Professor Cooke has been dealing with that unprincipled element, antimony, which has obdurately persisted in claiming two atomic weights, until he has successfully limited it to one. In connection with his laboratory-work, Professor Cooke is preparing a new edition of his "Chemical Philosophy." The results of his inorganic work have appeared from time to time in the publications of the Academy of Arts and Sciences.

Since the "Organic Laboratory" was established, in 1875, Professors Hill and Jackson have published twenty-five papers giving the results of their work, and have discovered one hundred new compounds. The discovery of new compounds, however, possesses as a rule no special importance, and is rather incidental to, than the result of, the main work. Two examples will indicate somewhat the character and object of organic investigations. The *composition* of uric acid has been long known to be $C_5H_4N_4O_3$, but its *constitution*—the exact arrangement of the atoms—has been uncertain. Chemists all over the world had endeavored to settle the question, but their failures resulted in eleven different formulæ for this one substance. Professor Hill, taking this uric acid, $C_5H_4N_4O_3$, marked one part by replacing H by CH_3 (methyl); then treating the acid so as to split it up, he determined to which part the methyl was attached, and, by continuing his treatment, was enabled to reduce the possible formulæ from eleven to three, with strong probabilities in favor of one. This possesses a practical value, inasmuch as it will lead to a knowledge of the method of formation of uric acid in the animal body. Professor Hill's work on "Fur-ferrol," found in the products of the distillation of wood, is interesting, as chlorophyll can probably be obtained from it.

An example of the curious subtilties of science is afforded by Professor Jackson's investigations of anthracene, which is obtained from coal-tar, and yields alizarine (madder-dye), used in dyeing pink and purple calicoes, Turkey reds, etc. Anthracene was known to consist of two hexagons of carbon with hydrogen-atoms attached, united by two other carbon-atoms. Professor Jackson proved, by making anthracene artificially, that these two carbon-atoms are united to adjacent corners in each hexagon, thus:



These are but stray examples of the researches that are constantly being made by Professors Hill, Jackson, and their assistants. Brombenzylbromides, parachlorbenzyls, and benzaldehyds, however, fascinating as they may be to chemists, would offer few charms to the general reader.

Since 1841 Dr. Asa Gray has devoted such leisure as he could command to his great work "The Flora of North America," a labor the magnitude of which only an experienced botanist can appreciate. Mr. Watson, Curator of the Herbarium, is assisting Professor Gray, and at present is classifying the flora of California. The new series of botanical text-books, edited by Dr. Gray, will shortly be completed. The titles will be as follows:

1. "Structure and Morphological Botany of Phænogamous Plants," by Dr. Gray.

2. "Physiological Botany" (Vegetable Histology and Physiology), by Dr. Goodale.

3. "Introduction to Cryptogamous Botany," by Professor Farlow.

4. "Natural Orders of Phænogamous Plants and their Special Morphological Classification, Distribution, Products," by Dr. Gray.

One of the most recent of Dr. Gray's botanical contributions to the Academy of Arts and Sciences was a paper on the "Characters of some New Species of Compositæ in the Mexican Collection, made by C. C. Parry and Edward Palmer," and a notice of "Some New North American Genera, Species, etc."

Professor Farlow's work in cryptogamic botany is doubly interesting on account of its direct practical application. At the Bussey Institution Professor Farlow has been investigating the diseases of plants, and latterly has been engaged upon algæ and fungi. Among his recent work is a paper on algæ for the United States Fish Commission, an examination of the causes of onion-smut and the diseases of trees for the Board of Agriculture, and an investigation of the algæ producing disagreeable tastes and smells in water, for the State Board of Health. His work resolves itself, speaking generally, into two kinds—one, the abstract descriptions and arrangements in families of algæ and fungi, and the other the detection of fungi in disease. As an example of the first, there is a European species of algæ which constitutes the green scum on stagnant water. Several different varieties may be found in different places, but they have all been discovered to belong to the same family. To illustrate the second, there is a certain kind of fungus on cedar-trees, but this has been ascertained to be only a first stage, and the fungus in its second stage is found upon several members of the apple family.

Professor Wolcott Gibbs has been carrying on researches on complex inorganic acids, and Professors Lovering and Trowbridge have been conducting purely physical investigations. Professor Trowbridge has introduced a method of instruction that necessitates a large amount of original research on the part of his students. This consists of lectures, given by the students instead of by the instructor, to the class. Although all the work at the Observatory really comes under the head of original investigation, the observations constantly taken in connection with the Observatory Time Service resolve themselves into mere routine work. An immediate and practical benefit is conferred by this Time Service, the signals of which reach Bangor, Lennoxville, in Canada, Albany, and New York, as well as different points in Massachusetts. The copper time-ball, held by a powerful electro-magnet at the top of the mast on the Equitable Life Assurance Building, Boston, is released at noon by the clock at Cambridge. During 1879 accidents caused a small error in its fall on two days only, and on three days it has been dropped at 12h. 5m. 0s.

The great equatorial of fifteen inches' aperture and the meridian circle whose telescope has an aperture of eight inches have been kept actively in use for the last three years. The former instrument has been devoted almost entirely to photometric work. The problem of astronomical photometry, roughly stated, is to determine the brightness of all the heavenly bodies, so that all may be compared with a single standard. Previous to the beginning of this work at the Harvard Observatory, photometric measurements had been made almost entirely upon the planets and brighter stars, and there was no definite knowledge of the amount of light emitted by the satellites and fainter stars. At the outset of the work several hundred measurements were taken of the brightness of the outer and inner satellites of Mars, which measures have been taken accurately nowhere else. The satellites of Jupiter and Saturn, including Hyperion, the faintest of Saturn's satellites, were similarly measured. In addition to measuring their brightness, a large number of determinations of the positions of the satellites were made. A comparison was also begun of the light of the sun and stars, with the idea of reducing all photometric measurements to a common standard—the light of the sun. This photometric work has been continued until the light of all the known satellites, except the two inner satellites of Uranus, has been measured.

One of the most important series of equatorial observations has been in connection with the eclipses of Jupiter's satellites. These phenomena have proved exceedingly valuable as a means not only of determining the orbits of the satellites themselves, but of measuring the distance of the sun or the velocity of light, and of obtaining terrestrial longitudes.

The observations of the mere appearance or disappearance of a satellite, however, can not be rendered sufficiently exact, and, to lessen the errors, photometric observations have been made of the satellites as they gradually enter or emerge from the shadow of Jupiter, using the planet itself or another satellite as a standard.

In order to furnish means for the comparison of the scales of stellar magnitude, employed by different astronomers in their estimate of the brightness of faint stars, a number of faint stars in the immediate neighborhood of the north pole were selected for photometric measurement, and a circular was distributed among astronomers requesting estimates of magnitudes of the same stars for comparison with each other, and with the results of the measurements made here. A series of measurements of all the planetary nebulæ has also been undertaken. This work with the great equatorial has necessitated the invention of a number of new photometric instruments, which have been devised by Professor Pickering and his assistants.

For nearly eight years Professor Rogers has been engaged upon one of the largest astronomical undertakings that has been successfully completed in this country. This is the observation with the meridian circle of the zone of eight thousand stars, between fifty and fifty-five degrees north, undertaken by this Observatory as its share in the determination of the position of the stars of the northern hemisphere. The observations were finished about a year ago, but some years will be required to complete the reduction and publication of this work.

The total number of observations for 1879 with the meridian circle, including about six hundred for the Coast Survey, was nearly three thousand. The scientists at the Observatory are now engaged in the task of determining the light of all the stars visible to the naked eye in the latitude of Cambridge. The meridian is used in observations like a transit instrument in connection with a new and elaborately designed photometer.

At the Museum of Comparative Zoölogy the staff of specialists is almost entirely occupied in the classification and arrangement of different collections and the publication of the results of their researches. The most important accessions during 1878 and 1879 are the extensive collections of the Blake dredging expedition, and the collections of birds, mammals, reptiles, and fishes, made by Mr. Garman at St. Kitts, Dominica, Grenada, Trinidad, St. Thomas, and Porto Rico, after he left the Blake. The Blake collections and specimens from the entomological, conchological, and ornithological departments are in the hands of well-known specialists for final investigation. Of the extensive work in progress it is impossible to give any details. The results are embodied in the extensive publications of the museum. Five volumes of bulletins have been published, averaging about a dozen papers each. The quarto publications will hereafter be issued as memoirs. The catalogues thus far published have been collected into Volumes I.–IV. of the memoirs. Five volumes of memoirs and the first part of the sixth have already appeared. The second part of the sixth and Vol. VII. are now in course of preparation or in press. Vol. VI. contains the great work upon which Professor Whitney is now engaged, "The Auriferous Gravels of the Sierra Nevada of California." The Sturgis Hooper Professorship of Geology, held by Professor Whitney, is noticeable as being founded solely for original research.

The dredging operations of the Coast Survey steamer Blake have not only aided zoölogical science by the information obtained in regard to echini, corals, crinoids, ophiurians, worms, hydroids, and others, but have added to geographical knowledge of the Caribbean Sea by showing the changes in form and distribution of lands along various groups of islands, and in the form of the land beneath the water. Professor Agassiz considers the deep-sea collections of the Blake the largest and most important ever made on this coast, and, when combined with the results of other expeditions sent out under the auspices of the Coast Survey, they make the collections at the museum but little inferior to those of the Challenger. During the coming summer Professor Agassiz will probably undertake another dredging trip in the Blake, following the course of the Gulf Stream to the north of the Bahamas, and dredging from the 100- to the 2,500- fathom line off the coast of the United States, so as to connect the isolated district with the deep-water fauna proper of the Atlantic.

Professor N. S. Shaler, Professor of Paleontology, in addition to his work at the museum, and as an instructor, has, since 1873, had charge of the Kentucky State Survey. Four volumes of reports and one of memoirs have been already completed, and one volume of memoirs and nine of reports are now in press. The recent writings of Professor Shaler are "The Origin and Nature of Intellectual Property," and several articles in the "Proceedings of the Boston Natural History Society," "The Atlantic Monthly," and "The International Review." The article by Professor Shaler in the latter magazine is entitled "Sleep and Dreams."

Scientific publications, based entirely or in part upon the entomological collection of the museum, are the new edition of the "Catalogue of the Diptera of the United States," by Osten-Sacken, published by the Smithsonian Institution, Part VIII. of the "Monographic Revision of the European Trichoptera," by R. McLachlan, published in London, and several papers by Dr. H. A. Hagen, the head of the department.

The recent work of Professor Langdell, Dean of the Lower School, is peculiarly rich and important. It includes a "Summary of Equity Pleading," a new edition of "Cases on Contracts," containing a summary of the law of contracts as developed in these cases, and a book on the "Law of Sales."

Professor Ames is engaged upon a work to be entitled "Bills and Notes," and Professor Thayer is at work upon a book on "Evidence."

Aside from his duties as professor in the Divinity School, Professor Abbot is a member of the American committee which assists the English Commission for revising the translation of the Bible. He is also a contributor to "The Unitarian Review," in which he has lately published a series of articles on "The Authorship of the Fourth Gospel," which are masterpieces of critical scholarship.

Mr. Allen is preparing a new edition of his "Hebrew Men and Times," and is also engaged upon a book of "Latin Composition."

During the administration of Mr. Winsor, some new features have been introduced into the management of the library, which, though hardly coming under the head of original work, are important and interesting. At intervals of a week or less, printed lists are struck off of the books received, and posted up for reference. These are collected and published monthly. A quarterly bulletin is issued, containing valuable bibliographical contributions by members of the faculty and the librarian. The most important publication of last year was the "Catalogue of Scientific Serials from 1633–1876," an octavo volume of three hundred and seventy pages, by Mr. S. H. Scudder, the entomologist, who is assistant librarian. This book constitutes Vol. I. of the special publications of the library.

The instructors in the various departments indicate the books which their students will need to consult frequently, and all such books are reserved and placed in special alcoves where they can be freely consulted during library hours. One or two advanced classes meet and work at the library in the midst of the reference-books bearing on their subjects. The tendency of this method necessarily is to excite a spirit of investigation in the student, and, to a good degree, students as well as professors pursue original research.

It would seem unfair to leave Cambridge without a glance at the beautiful gymnasium, the lack of which was so long a heavy cross for Harvard students.

The medical director has devised various new and yet wonderfully simple forms of apparatus for strengthening the muscles of the neck, back, loins, and abdomen, as well as of the arms and legs. A physical examination and carefully supervised gradation of exercise distinguish the new era of Harvard muscular Christianity from the old.

At the medical school the largest amount of original investigation is carried on in the physiological and chemical laboratories. In the former a number of new forms of apparatus are in use, which have been designed by Professor Bowditch and his assistants. Among these are an apparatus for keeping animals alive by artificial respiration; a dog-holder, cannulæ for observations on the vocal cords of animals, without interfering with their natural respiration; unpolarizable electrodes used in studying certain problems in the physiology of the nervous system, a new form of apparatus for barometric measurements, and a novel plan for measuring the volume of air inspired and expelled in respiration. A new form of plethysmograph has been devised by Dr. Bowditch. This is an instrument for measuring the changes in the size of organs, either hollow or solid, which are produced by variations in the conditions to which they are subjected. The essential part of Dr. Bowditch's invention is a contrivance by which fluid is allowed to flow freely to and from the organ to be measured without changing its absolute level in the receptacle into which it flows, while at the same time a record is made of the volume of the fluid thus displaced.

The more important work going on in the laboratory at the time of my visit consisted of experiments in regard to respiration, with special reference to the functions of the glottis and epiglottis, and trials of disinfectants with a view to ascertaining the temperature necessary to kill germs. A series of experiments was also in progress for testing the porosity of various stones used in building.

The results of the original work performed here have been recently published, together with an account of the physical apparatus in use at the school. Accounts of the most important investigations carried on during the last year are contained in the following papers: "Growth as a Function of Cells: Preliminary Notice of Certain Laws of Histological Differentiation," by C. G. Minot; "Effects of the Respiratory Movements on the Pulmonary Circulation," by H. P. Bowditch, M. D., and G. M. Garland, M. D.; "Pharyngeal Respiration," by G. M. Garland, M. D.; "Functions of the Epiglottis in Deglutition and Phonation," by G. L. Walton. This paper shows that the removal of the epiglottis does not seriously affect deglutition, and therefore it is not necessary for that process. The epiglottis, however, plays an important part in forming and modifying the voice, taking different positions during vocalization, changes of pitch, quality, and intensity.

In the chemical laboratory I found that Professor Wood had been examining the water-supply of Cambridge; and was then engaged in the investigation of the extent to which arsenic is being used in the manufacture or ornamentation of articles in general use, such as wall-paper, confectionery, playthings, etc. The results of this work will be published in the next report of the State Board of Health. Professor Wood is also writing the addition to "Ziemssen's Cyclopædia" on the subject of toxicology.

Dr. William B. Hills was engaged upon a special investigation in regard to the localization of arsenic in the animal economy.

The most important feature of original work at the school of late years has been Dr. Bigelow's introduction of the new operation of litholapaxy.

A number of interesting papers have been recently written by members of the faculty, some of which contain new discoveries of considerable scientific importance. I cite two: "Effects of Certain Drugs in increasing or diminishing Red Blood-Corpuscles," by Dr. Cutter; and "Alterations in the Spinal Cord in Hydrophobia," by Dr. Fitz.

The School of Agriculture and Horticulture, called "The Bussey Institution," is located on the sunny slopes of Forest Hills, about five miles southwest from Boston. The labors of the professors connected with this institution have been even more in the line of original research than of instruction, though of late the lack of a sufficient endowment has interfered with the quantity of work and the publication of the results.

A number of exceedingly interesting and valuable papers, however, have appeared in the "Bussey Bulletin," the titles of which give some indication of the character of the work. I give a few of the more important: "Hybridization of Lilies," by Professor Parkman; "Diseases caused by Fungi"—Professor Farlow; "Examinations of Fodders," "Trials of Fertilizers," Prominence of Carbonate of Lime in Soil-Water," "Importance as Plant-Food of the Nitrogen in Vegetable Mold"—Professor F. H. Storer; "The Potato-Rot," and "The Black Knot" (of plum- and cherry-trees)—Professor Farlow.

The Bussey Institution ends my outline of the original work that has been carried on among Harvard professors mainly during the last year. Purely literary work I have endeavored to avoid, but I may say, in passing, that Dr. O. W. Holmes has recently finished an elaborate examination of the life and writings of Jonathan Edwards. Another feature worthy of special attention is the growing tendency with instructors to develop original research among the students. This is particularly noticeable in the departments of political economy, physics, history, and in some of the electives in mathematics. The case-system in the Law School is the purest example of an effort to cultivate independent thought. Mere memorizing is becoming by degrees a matter of secondary importance, and instructors are aiming to train their pupils to think for themselves, and to pursue lines of investigation outside of the beaten routine-path. Necessarily, the attainment of this result must prove in the highest degree beneficial. The cultivation of the powers of perception and insight becomes of inestimable value in fitting the student for the successful accomplishment of the duties of real life. As yet only a beginning has been made in training students to independent habits of thought, but this may fairly be considered the forerunner of a promising future. With the development of a thorough system of physical culture and the growth and prevalence of original investigation rather than memorizing for examinations, the Harvard student may perhaps obtain the ideal liberal education, when "his body is the ready servant of his will, and does with ease and pleasure all the work that as a mechanism it is capable of; his intellect is a clear, cold, logic-engine, with all its parts of equal strength, and in smooth working order—ready, like a steam-engine, to be turned to any kind of work."

The original work of the instructors, hastily sketched in this article, speaks for itself, and needs no word of explanation or commentary. That so much should be accomplished, however, outside of routine-work is indeed surprising and creditable, when we consider that the primary duty of these professors is an advanced teaching which absorbs both time and energy. It becomes evident that a life of scholastic seclusion is neither a life of monotonous drill-work nor one of dilettant leisure, and it is clear that American scholarship can no longer be called unproductive. Comparisons inevitably suggest themselves. Harvard possesses a larger number of professors engaged in independent research than any other institution in the country, and to Harvard, I believe, belongs the honor of leading all American universities in original work.

GEOLOGY AND HISTORY.

By Professor GRANT ALLEN.

THE science of human life has been the last to recognize that minute interaction of all the sciences which every other department of knowledge now readily admits. We allow at once that no man can be a good physiologist unless he possesses a previous acquaintance with anatomy and chemistry. The chemist, in turn, must know something of physics, while the physicist can not move a step until he calls in the mathematician to his aid. Astronomy long appeared to be an isolated study, requiring nothing more than geometrical and arithmetical skill; but spectrum analysis has lately shown us its intimate interdependence upon chemistry and experimental physics. Thus the whole circle of the sciences has become a continuous chain of cycles and epicycles, rather than a simple sequence of unconnected and independent principles.

History, however, still stands to a great extent outside the ever-widening sphere of physical philosophy. It is comparatively seldom that we see an historian like Dr. Curtius acknowledging the interaction of land and people upon one another's character and destiny. More often we find even the modern annalist writing in the spirit of Mr. Freeman, as though men and women formed the only factors in the historical problem, and the great physical powers of Nature counted for nothing in the game of human life. Yet a few simple instances will show at once the fallacy of such a view. If the ancestors of the Hellenic people had gone to the central plains of Russia instead of to the island-studded waters of the Ægean, could they ever have produced the magnificent Hellenic nationality with which we are familiar? Was not their navigation the direct result of their geographical position on the shores of an inland sea, intersected by jutting peninsulas, and bridged over by a constant succession of islands, each within full sight of its nearest neighbors? Was not their polity predetermined in large measure by the shape of their little mountain valleys, each open to the seaward in front and closed by a natural barrier of hills in the rear? Could their plastic genius have risen to the height of the Olympian Zeus and the Athene of Phidias if they had possessed no material for sculpture more tractable than the hard granite of Syene? While we allow that the Aryan blood of the Hellenes had much to do with the differences which mark them off from the Negroid Egyptians, can we doubt that Hellenic civilization would have been very different if the settlers of Attica had happened rather to occupy the valley of the Nile; and that the Egyptians would have become a race of enterprising sailors and foreign merchants if they had chanced to make their homes on the shores of the Cyclades and the Corinthian Gulf?

Or, again, let us look for a moment at Britain. Who can suppose that the destiny of our country has not been profoundly affected by the existence of great coal-fields beneath its surface? Even if we possessed no mineral wealth, it is probable that our geographical position would still have insured us a considerable commercial importance as the carriers of the civilized world. Britain happens to occupy the central point in the hemisphere of greatest land, and this fact, aided by its insular nature, could not fail to make it a great mercantile country as soon as navigation, nursed in the Mediterranean, had advanced sufficiently to embrace the whole ocean-coasts of Asia, Africa, and America. But without coal and iron we should have been mere merchants, not manufacturers. London, Liverpool, Glasgow, and Southampton might possibly have been not inconsiderable marts for exchanging the products of other countries, and for balancing the trade in raw cotton or sugar from India and America against the textile fabrics and the hardware of France and Belgium. But we should have had no Birmingham, no Manchester, no Sheffield, no Leeds, no Bradford, no Paisley, no Belfast. Our population would not have reached one half its present size. Lancashire, the West Riding of Yorkshire, and the busy mining district of South Wales would be as thinly inhabited as Merionethshire and Connemara. The Black Country would be a quiet pastoral and agricultural region like the remainder of Warwick and Stafford. We should have no great towns except on the seaboard and the navigable rivers, and even these would only attain a fraction of their existing dimensions. Most of our people would be engaged in farming, and there would be no great wealthy class to crowd into Brighton, Scarborough, Cheltenham, Torquay, and the Scottish Highlands.

But this is not all: the difference in our national character would no doubt be very great. Coal has stimulated our inventive faculties and our enterprise, and has given an indirect impetus to science and art. Without it we should have had fewer mechanical improvements, fewer scientific discoveries, fewer railways, fewer colleges and schools. All these things have reacted upon our general level of intelligence and taste, and have enabled us to hold our own among the most advanced European nations. But without coal and iron we should have fallen back to somewhat the same position as that now held by Holland or Scandinavia, allowance being made for a larger territory in the first case, and a thicker population in the second. Our comparatively insignificant numbers would reduce us from the rank of a first-class European power to that of a nation existing on sufferance. Our army and navy would be smaller; our Parliament less important and less stimulating to high ambitions; our churches, our bar, our medical faculty less advanced in the fore-front of thought. Thus we should probably suffer in every respect, producing both absolutely and relatively fewer great men, either as thinkers, administrators, discoverers, inventors, or artists. For, when once a nation has fallen behind in the race, the audience addressed becomes smaller, the competition less keen as an incentive to effort, the rewards of success decrease in value, and the general atmosphere of example and rivalry deteriorates in power. Where few books are written, few investigations undertaken, few works of art produced, few and still fewer care to aspire toward a forgotten ideal. Thus, without coal, Britain might have declined from the England of Shakespeare, Milton, and Newton, just as other countries have declined from the Hellas of Pericles and Plato, and the Spain of Cervantes and Velasquez.

The relation between physical conditions and history in its wider acceptation being thus fundamental, it may be well to consider in somewhat greater detail the special reactions of a single tolerably definite portion of the natural environment upon human development. For this purpose we may choose the science of geology. It might seem at first sight that geological facts had very little to do with the course of history. Rocks and clays, lying often far beneath the surface, and comparatively disregarded till a late stage of civilization, would appear far less important in the evolution of mankind than plants and animals, geographical situation and meteorological conditions. But, though doubtless of inferior practical interest to these superficial phenomena, the geological constitution of the soil is yet pregnant with innumerable reactions upon the life of human beings who dwell upon its surface. I hope to show in the sequel that the rocks or minerals which lie beneath the thin coating of earth and vegetation have always exerted an immense though often unsuspected influence upon the history of man. And I shall choose most of my examples from well-known facts of the British Isles, only diverging elsewhere very occasionally for the sake of more striking or more conclusive instances.

To begin with, it must be premised that geological conditions were of comparatively less importance in very primitive times, and have increased in their practical relation to humanity with every additional step in general culture. This is only what we must expect from the nature of the case. Man's connection with his environment has necessarily grown more and more complex as his evolution proceeded. Soil becomes a matter of interest sooner than building-stone; potter's clay precedes copper or iron ore as a valuable object; metals of every kind are earlier required than coal. The mere savage needs nothing more from the mineral world than flint for his arrow-head and ochre for his personal adornment. A little later he requires bronze for his hatchet, gold and amber for his rude jewelry, clay for his hand-molded earthenware. A still more advanced race will learn to prize silver for coins, lapis lazuli for gems, brick-earth for Assyrian temples, granite for Egyptian colossi, marble for Hellenic sculpture, and iron for Roman swords. Only at a very late period of development will man begin to be largely affected by the neighborhood of zinc, lead, and mercury, of rock-salt, kaolin, and plumbago, of slate-quarries, marl-pits, and pipe-clay beds. Last of all will come the economic employment of coal, which in our own island has caused the aggregation of densely massed populations around the great centers of Glasgow, Manchester, Leeds, Sheffield, Newcastle, and Birmingham.

How general is the relation in early stages of civilization we can see from the comparatively close similarity between the life and arts of all the lowest savages. How special it becomes in advanced societies we can see when we consider the cases of Bethesda growing up by the side of the Penrhyn slate-quarries ; of Broseley, entirely engaged in the manufacture of clay tobacco-pipes ; and of Northwich, Middlewich, and Nantwich supporting themselves by mining rock-salt.

Nevertheless, even at the earliest period, geological conditions must have largely influenced human life. Tribes which lived among rugged granite or limestone mountains must have been very differently circumstanced from those which ranged over level tertiary lowlands, or settled on the alluvial deltas of modern rivers. During that primitive epoch which Sir John Lubbock has christened the Palæolithic age, when man first dwelt in Britain, we see traces of such primeval differentiation. The naked or skin-clad savages, who then hid among the caves of southeastern England, were ignorant of all the metals, as well as of pottery, and only employed rudely chipped weapons of unground flint. The neighboring forests then contained the mammoth and the woolly rhinoceros, the urus and the musk-ox, while the hippopotamus still basked on the banks of the Ouse and the Thames. But man appears at that period to have been wholly confined to the southeastern corner of England, from the coast of Devonshire to that of Lincoln. This district roughly coincides with that in which he could obtain flints for the manufacture of his weapons ; and it also comprises the most level portion of Britain, where he might find comparative security and well-stocked hunting-grounds among the low-lying jungles of the eastern counties, the Thames Valley, and the tertiary plains of Hampshire. He does not seem at this early age to have ventured among the wild primary hills of Cornwall, Wales, the Pennine chain, and the Scottish Highlands, but rather to have clung about the river-fisheries and the flat shores of the southeast. Perhaps the bare and treeless chalk downs which run from Beer in Devonshire to the Norfolk coast, backed by a forest-belt on the oölite in the rear, may have checked his westward advance through the fear of meeting the cave-lions and other savage wild beasts of the preglacial period on the open plain.

At a far later date, when man had progressed from the hunting to the pastoral stage, and had learned to fashion weapons of polished stone or bronze, which made him the acknowledged master of the brute creation, it is clear that a great change must have taken place as regards the relation to geological conditions. And in Britain the men of this later period certainly spread over the whole country, gathering most thickly, it would seem, where pasturage was easiest for their herds and flocks. This would naturally be upon those same undulating chalk downs which were doubtless objects of terror to the earlier race. Hence we find the tumuli and other memorials of the Euskarian and Keltic inhabitants—belonging either to the neolithic, the bronze, or the iron age—most thickly clustered around the great monument of Stonehenge on Salisbury Plain, among the downs about Brighton or Lewes, and on the sides or summits of the Yorkshire and Lincolnshire wolds. In those days and for many centuries after, the Weald of Kent lay as a wild forest-belt between the open chalk country to the north and south; while the primary hills and the river valleys still consisted for the most part of unbroken underbrush and woodland. Even in these early times, however, a commerce based upon geological differences had already sprung up: for the beautiful jade, employed as material for the finest hatchets, has been recognized as coming from the Kuen-Lun Mountains of Central Asia, while amber was already imported from the banks of the Baltic. Within Britain itself the Cornish tin-mines probably supplied the metal which mingled with copper to form the bronze implements of all Western Europe. An industrial population must even then have gathered with comparatively considerable density above the ores of the Land's End, while the valley of the Thames remained a mere desolate jungle wandered over by a few stray families of savage hunters.

Agriculture must first have developed itself over the whole world on low alluvial ground. Hence we find that all the great early civilizations occupy river valleys—such as those of the Nile, the Euphrates, the Ganges, the Indus, and the Hoang-Ho. Here alone can large masses of men obtain subsistence, before navigation and scientific agriculture have reached a considerable stage of evolution. Here, too, the density of the population and the level nature of the soil permit the growth of those vast despotisms under which alone an early society can be organized with any high degree of internal diversity. But just as navigation, nursed on inland and island-studded seas, spreads afterward to the wider oceans, so agriculture, nursed on well-watered alluvial plains, spreads afterward to drier, rockier, or more mountainous districts. In the desert uplands of the Punjaub, cultivation exists wherever wells can be sunk, even at immense depths, and the industrious Jat peasantry work ceaselessly day and night by relays, each family raising the precious water to fertilize its own little plot, for a stated number of hours out of the twenty-four. But such industry presupposes a long training in more fertile soils, and a heavy pressure of population on all the earlier occupied alluvial lowlands. So too in Britain, a primitive agriculture would have despaired of raising corn upon the bare sides of the Chiltern Hills, and only modern scientific farming has turned the boggy upland expanses of the Cheviots and Lammermoor into flourishing tillage. Accordingly, we might expect that the growth of agriculture would bring geology and human development into still closer connection within our island.

Geologically, Britain falls into two well-marked divisions—the northwestern primary tract, and the southeastern secondary and tertiary region. The boundary between them may be roughly marked off by a line running from the mouth of the Tees to the mouth of the Exe. Northwestward of this line we have the whole of Scotland, the Pennine region of England, the Welsh mountain system, and the peninsula of Devonshire and Cornwall. Southeastward we have the whole level country of England, comprising the plain of York, the great central plateau, the Fen district and the eastern counties, the valley of the Thames, and the watershed of the south coast.

Now, it is not too much to say, that by far the most fundamental fact in the annals of Britain, since the dawn of written history, is the great revolution which has exactly reversed the relative importance of these two divisions. Yet what are called histories of England at the present day utterly ignore that revolution. In the Roman period and the middle ages, the most valuable and most populous part of Britain was the secondary and tertiary lowland: at the present day, the most valuable and most populous part is the primary division to the north and west. And what gives this revolution its greatest ethnological interest is the fact that while the secondary tract roughly corresponds with the Teutonic portion of Britain, the primary tract roughly corresponds with the Keltic or semi-Keltic portion.

As early as the time when Caius Cæsar, the Dictator, landed in our island, these two great divisions had already shown their differentiating characteristics. The Britons of the southeastern country, consisting of open and easily cultivable plains, had advanced to the agricultural stage, and were comparatively dense in their pressure upon soil, with fixed habitations and considerable towns. The northwestern tribes were still pastoral nomads or hunters, dwelling in movable villages, and having mere empty forts on the hill-tops, to which the whole population retreated in case of invasion. The difference thus expressed continued more or less marked throughout the whole historical period, until the use of coal effected that extraordinary revolution by which primary and industrial Britain has at length asserted its superiority to the level agricultural southeast.

Under the Romans Britain became a corn-producing and grain-exporting agricultural country, like the America of our own day. And just as the valley of the St. Lawrence and the northern Mississippi basin now form the most important wheat-growing part of America, so the valleys of the greater rivers formed the most important part of Roman Britain. The plain of York, formed by the Ouse and other tributaries of the Humber, is the largest low-lying corn-field and meadow-land in our country. It consists mainly of triassic strata, overlaid in the lower reaches by a deep bed of alluvium. In the center of this rich agricultural tract lay the Roman provincial capital of Eboracum. Another wealthy region is the post-tertiary level of the eastern counties; and here the colony of Camalodunum lay surrounded by numerous villas of rich land-owners. The tertiary valley of the Thames shows its importance by including the considerable cities of Londinium, Verulamium, and Rhutupiæ. Other Roman towns—Lincoln, Cirencester, Bath, and Dorchester—filled up the rich oölitic and green-sand belt of central England; while Winchester overlooked the tertiary vale of the Itchin at Southampton, and took its name of Venta Belgarum from the agricultural lowland at its doors. We may gather from the Roman historians that the occupation of southeastern Britain was real and thorough. The native population was reduced to serfdom, and the country became a mere feeder of Rome or of the Gallic cities.

Primary Britain, however, seems never to have fallen into so miserable a condition. The Roman supremacy was here probably confined to a mere military occupation, like our own occupation of Kumaon or the Simla Hills. Caledonia never fell into their hands, and even in Wales and the Pennine chain we find only military stations, like Isca Silurum or Segontium, not large cities like London, York, and Lincoln. Even where the Romans thoroughly penetrated the primary region, as in Cornwall or the Forest of Dean, it was always for a geological reason, to secure the mines of tin or iron. This difference, I believe, had almost as much to do as geographical position with the subsequent relations of the Britons to the English invaders. While the servile herd of the Belgian, Icenian, Trinobantian, and Brigantian country, demoralized by Roman centralization, fell easily before the Jutish or Anglian pirates, the more independent mountaineers of Wales, Cumbria, and Strathclyde long resisted the English onslaught, and only at last succumbed as free subject races, instead of being enslaved or exterminated like their eastern fellow countrymen. The Scottish Highlands not only retained their own independence, but even gave their kings to the Teutonic Lothians. Granite naturally makes freemen, as alluvium naturally makes slaves.

When the English settled in southeastern Britain, they occupied for the most part the secondary and tertiary plain. But they also pushed northward into the primary region up to the Firth of Forth, as the Romans had done before them. The Teutonic invaders, in other words, took the best agricultural lands for themselves, while the Kelts were driven back into the rugged primary tract of hill and forest. Throughout the middle ages, agriculture and grazing formed the staple English industries. Accordingly, during the early English period, we find all the more important towns occupying the cultivable valleys or gentle plains. Canterbury and Rochester, the two Kentish capitals, stand in the midst of tertiary lowlands; London, the final royal city of the West Saxon kingdom, lies surrounded by a similar tract; the Oxfordshire Dorchester, first home of the Wessex kings, is on the border of the rich vales of Aylesbury and Oxford; Winchester, their later seat, commands the valleys of the Itchin and the Test. Norwich, Bury St. Edmunds, and Ipswich were important centers for the East Anglian drift. Peterborough and Ely rose among the levels of the Nen and the fens of the Ouse. Lincoln, Oxford, and Chippenham stood upon the great central oölitic belt. Cambridge occupied a low-lying corner of the cretaceous system. Exeter, Lichfield, and Chester were girt round with the fertile triassic meadow-lands. York still remained the capital of the north, and the metropolis of a kingdom which long retained the foremost position held by the north under Roman rule. These were the great cities of England before the Norman Conquest, and not one of them stands upon a primary formation. All of them, save only London, have now sunk to the position of mere cathedral cities, university towns, or agricultural centers. But Edinburgh, Glasgow, Manchester, Leeds, Sheffield, Newcastle, Bristol, and Cardiff, the great cities of to-day, are all built upon primary rocks; while the only two important modern towns which rest on later strata are Birmingham, on the borders of the Black Country coal-field, and Liverpool, which lives by conveying the cotton of America to the great Lancashire colliery district around Manchester, Rochdale, and Oldham.

In the later middle ages England became a wool-stapling country. Bales of wool were shipped from the Orwell for Flanders and Italy, as they are now shipped from Australia for Leeds and Bradford. This was the first step toward making Britain a commercial country. Before the Norman Conquest it had been an essentially agricultural and self-sufficing community, growing all that it required to meet its own simple needs, and neither exporting nor importing goods to any noticeable extent. But the wool export created a foreign trade. Ports sprang up along the south and east coasts, from Dartmouth, Topsham, and Lyme Regis to the now forgotten haven of Ravenspur-on-Humber, the precursor of our modern Hull. This trade gave importance to the chalk districts, high sheep-walks now the barest and least inhabited portion of southeastern England. Not a single town of any pretensions at present occurs in any part of the downs or wolds. But Dorchester, Shaftesbury, Old and New Sarum, Winchester, Lewes, Reading, Wallingford, Cambridge, and Beverley, were all places of great mediæval importance, and all stand within the cretaceous area. Other wool-growing tracts of course possessed a similar value.

A few more special agricultural features of the various secondary or tertiary geological formations may here be fitly introduced. The Trias and other "Poikilitic" strata, running across England from the Tyne to the Exe, form beautiful undulating country, comprising much of the best wheat-growing and pasture land, and famous for the production of cheese. In this belt lie the vale of York, the Trent and Severn Valleys, the Cheshire Plain, and the vales of Exeter and Taunton. An outlier forms the valley of the Eden at Carlisle. The Lias, which follows the Poikilitic series to the southeast, is a good soil for corn and apples, but also produces the most excellent cheese in England, as Mr. Woodward has pointed out. Along the Severn bank it furnishes the double Gloucester; at Melton Mowbray and Leicester it produces Stilton; and in Somersetshire it unites with the triassic red marl to yield the Cheddar. The fruitful vales of Eversham and Gloucester belong to this formation. The Oölite gives us the rock known as cornbrash, which disintegrates into a splendid wheat-bearing soil, naturally manured by its large quantities of phosphate of lime, the so-called bone-earth. The Oxford Clay, on the other hand, is poor and hard to cultivate, so that most of it lies under permanent pasture. It forms the sheep-feeding vale of Blackmore, in Dorset. The Kimmeridge Clay, in like manner, does not repay cultivation, and is mostly employed for meadow or woodland. The Wealden, forming the great trough between the North and South Downs, is another of the infertile soils. It remained a great wood, the Andredesweald, or Forest of Anderida, for a long period after the English conquest, and the local names of the district still retain their forestine terminations of *hurst*, *ley*, *den*, or *field*. Even at the present day the Weald is damp and clayey land, little tilled, and either laid down in pasture or given over to furze and heath. The Gault makes good grazing-lands, and the Upper Greensand is in every respect a fertile formation. These two series yield the rich Vale of White Horse, through which the Great Western Railway runs between Swindon and Didcot, as well as the vale of Aylesbury, whose name has become synonymous with pure milk. The Chalk supplies us with South Down mutton, said to owe its excellence not so much to the pasture itself as to a small land-snail (*Helix virgata*) which the sheep devour in great numbers.* The London clay, though stiff, can be made to yield good crops. Drift forms

* These little mollusks themselves abound upon chalky soils, and are found nowhere else, because they require large quantities of calcareous matter to form their banded shells, while other species with more horny coverings live on soils where less lime can be obtained. No snails can inhabit the limeless district of the Lizard in Cornwall. So minute are the interpendences between every portion of organic and inorganic nature.

the great East Anglian plain, while the Fen country, the Somersetshire levels, and Holderness consist mainly of alluvium. Thus we see that, little as the mediæval farmer suspected it, the distribution of his corn-fields and pasture-lands, his orchards and sheep-walks, nay, even of the royal forests and the barren heaths, was finally dependent upon underlying geological conditions.

Even in mediæval and agricultural England, however, certain particular spots acquired a special industrial character from the nature of the subjacent strata. The occurrence of fuller's earth in the Stroud Valley and near Bath and Bradford gave rise to the west country cloth-trade. Salt was pumped from several inland wells in the Trias at Droitwich in Worcestershire, at Northwich, Sandbach, Middlewich, and Nantwich in Cheshire, and at Shirleywich in Staffordshire. The bays in which sea-water had been evaporated to yield salt had been known as "wyches," and the same word was applied to the new wych-houses of the interior. Clay suitable for potteries was found in many places, and naturally produced a small trade. But mines were little worked, and building-stone, of which more must be said hereafter, formed almost the only other geological differentiating factor between various districts.

The change to the modern industrial distribution is far too large a subject to be treated otherwise than quite cursorily here; but a few traits of the change may perhaps be sketched with a rapid pen. In Britain mineral wealth is almost universally connected with the primary formations. Our coal more especially has formed the great central pivot upon which turns the whole manufacturing and commercial system of the country. As soon, therefore, as the use of steam began to revolutionize our industrial world, the primary tracts of England, Wales, and Scotland, rose to the highest importance. The population of Britain suddenly found itself turned back upon the Keltic and coal-bearing regions. A slight classification of the various great towns of modern Britain according to the coal-fields in which they stand, or on which they depend, will serve to show the vastness of the revolution.

In or around the Scottish coal-field stand Glasgow, Paisley, and Greenock. Above the Tyne colliery region are Newcastle, North Shields, and Durham, while close at hand lie Sunderland, Stockton, Darlington, Middlesborough, and the Cleveland iron district. The Lancashire field incloses Manchester, Blackburn, Wigan, Bolton, St. Helens, Burnley, Middleton, Oldham, Rochdale, and Ashton, with Liverpool for its port, and Preston and Macclesfield upon its outskirts. An outlier contains Stoke-upon-Trent and Newcastle-under-Lyne. The West Riding coal-field includes Leeds, Bradford, Wakefield, Barnsley, Sheffield, and Chesterfield, while Huddersfield, Nottingham, and Derby hang upon its border, and Hull supplies it with an eastward outlet. The Staffordshire tract comprises Wolverhampton, Bilston, Dudley, Wednesbury, and Walsall, with Birmingham for its real center. Other carboniferous deposits occur in Coalbrookdale, in the crowded South Wales district, and near Bristol. If all these are put together, it will be seen that they compose almost all the great foci of British life and manufactures at the present day.

On the other hand, what are the great towns in the secondary and tertiary southeastern tract? London, the main distributing center, preserved by its navigable river, and its official importance. Southampton, a convenient Indian and South American port. Plymouth and Portsmouth, two government naval stations. Chatham, an artificial creation for purposes of war. Scarborough, Brighton, Cheltenham, Bath, and half a dozen other lounges for the moneyed classes. All these ultimately depend for existence upon the wealth created elsewhere. Leicester is almost the only town in purely Teutonic England which now earns a good livelihood by industries unconnected with the sea or with warlike preparations. Turning to the north, Edinburgh survives by its traditional position as a metropolis and as the center of the Scottish Church, the Scottish law, and to some extent the Scottish aristocracy, as well as by its possession of a university and a great cultivated society. But Edinburgh itself stands on a primary site.

The specialties of the modern system are far too numerous to allow even of passing exemplification. Here coal, there iron, in other places lead or tin, forms the source of wealth and the determining cause of human aggregation. The potteries draw men to Staffordshire; finer clays produce the ware of Worcester, Lambeth, or Dunmore. Flags for paving are largely worked in North Wales. Lime from blue lias keeps alive more than one small seacoast town. Even gold is mined near Dolgelley in Merionethshire. Phosphate of lime is collected as mineral manure. Cutler's green-stone and beds of jasper are found among the Cambrian rocks. Millstones, hearthstones, and fire-clay are other useful economic products. Terra-cotta is made at Watcombe, near Torquay. Epsom salts are manufactured from magnesian limestone on the Tyne. Slates for roofing, plumbago, Cairngorm pebbles, afford occupation in other parts to quarrymen and lapidaries. Glass can only be made where flints are obtainable. Whitby derives a small fortune from alum, jet, and the sale of fossils. Guernsey lives largely by exporting its granite as road metal to London. Whetstones supply an industry to Whittle Hill, and slate-pencils to Shap in Cumberland. But perhaps the strangest trade of all is that of the gun-flints, still manufactured at Brandon and Norwich to supply the savages of Africa, whither all the old flint-locks of Europe were shipped on the invention of percussion caps.* The water-supply everywhere depends upon geological conditions. Even our pleasure resorts and

* I owe this, with many other facts, to Mr. H. B. Woodward's interesting "Geology of England and Wales."

watering-places owe their attractions to similar considerations, as we can see when we examine the igneous masses of the Scotch Highlands, which form the chief heights of the Grampians; or when we remember that the self-same Cambrian rocks recur in the loveliest part of North Wales and in the Westmoreland lake district. So too in Devonshire, the regular tourist tract from Ilfracombe to Lynton and Lynmouth lies through the wild Devonian strata, which, interspersed with granite, once more reappear on the other tourist coast-line from Torquay to Land's End. Those who admire Ramsgate and Margate, with their bare, treeless downs and white chalk-cliffs, may also content themselves with the similar scenery of Dover, Folkstone, Eastbourne, or Brighton; but a different type of mind will prefer the wooded vales of Hastings, where the Weald comes down with its pleasant broken country to the seashore.

One last word may be given to the influence of geology upon art. We can hardly deny that the whole æsthetic development of Egypt must have been largely affected by its alternation between solid granite and the mud of the Nile. So, too, the Parthenon and the Apollo must have owed much to the marble of Paros and Pentelicus. China has doubtless been greatly influenced by the presence of kaolin clay. In Assyria, brick necessarily formed the chief building material; and in Upper India the monasteries and stupas of the Buddhist Emperor Asoka are still recognized by their huge, sun-dried bricks. Chryselephantine art could never alone produce high results; marble and alabaster would naturally yield far more elevated works. In Britain we may look for similar effects of the geological environment.

As early as the age when Stonehenge was piled up, building-stone was selected for special purposes, since the outer circle of that prehistoric monument consists of the Sarcen bowlders of the neighboring plain; but the inner pillars are of diabase, and have been brought from some unknown distance. During the middle ages Caen stone was frequently imported for building churches or other important architectural works. Before the Norman Conquest, however, most English buildings were of wood, so that, "to timber a minster," not to build a church, is the good early English expression of the chronicle. In chalk districts, at a later date, broken flints were often employed, and they give a mean appearance to the abbey ruins and churches at Reading, as well as to most of the older edifices at Brighton. Oxford, however, on the Oölite, is happily built of good native or imported stone. In modern times, London, standing in the midst of the brick-earth, has fallen a victim to the miseries of stucco,* until the Queen Anne revivalists have endeavored to restore an honest red brick; whereas Edinburgh, surrounded by excellent building-stone, has been able to do justice to its magnificent natural situation, and

* Parker's cement, manufactured from the septaria of the London clay, is answerable for the outer coating of our West-end houses.

Aberdeen has clad itself in the stern but not unattractive gray and blue of its own solid granite. To the Caen stone, the Bath stone, and the Portland stone we owe half our cathedrals and abbeys, whose delicate tracery could never have been wrought in Rowley rag or Whin Sill basalt. The architecture of granite or hard limestone regions is often massive and imposing, but it always lacks the beauty of detailed sculpture or intricate handicraft. The marble lattice-work of the Táj or the "prentice's pillar" of Roslyn Chapel is only possible in a soft and pliable material.

Thus we see that agriculture and manufactures, art and science, are all largely influenced by geological conditions. Indeed, it would not be too much to assert that, after climate and geographical situation, geology is the greatest differentiating agent of national character. Every people is primarily what it is in virtue of the heredity it derives from the common ancestors of its whole stock; but, so far as it differs from other descendants of the same stock, the differences must mainly have been caused by those three great natural agencies, acting and reacting in conjunction with the original hereditary tendencies. The immense complexity of such actions and reactions renders them difficult to trace in detail; but the general principle which they illustrate can hardly be missed by those who read history with a wide and comprehensive glance.—*Fraser's Magazine.*

THE CINCHONA-FORESTS OF SOUTH AMERICA.

By HENRY S. WELLCOME.

In the month of June, 1879, I visited some of the principal cinchona districts of South America. The following notes are based upon my own observation and information obtained from native bark dealers and gatherers. I shall speak more particularly of the cinchona-forests of Ecuador, once the only source of bark, and still yielding large quantities. The bark territory is divided into the district known as Bosque de (forest of) Guaranda and Bosque de Loja.

The Bosque de Guaranda is a vast forest, extending from about 1° north to 2° south; it covers with its rich verdure the western slopes of Chimborazo, and the outlying ranges of the Cordilleras to more than ten thousand feet above the sea-level, encompassing within its higher limits the picturesque city of Guaranda. This district is the source of most of the barks exported from Guayaquil, and has never yet been fully explored. Guayaquil, the main shipping port of Ecuador, is a city of thirty thousand inhabitants, situated on the Guayaquil River, sixty miles from its mouth. The river is navigable to this point by large ocean-steamers. The southern extremity of the Bosque de Guaranda is reached at Pueblo Nuevo, a small town on one of the eastern branches of the Guayaquil River, about seventy-five miles from this town. A small steam-launch plies between the places.

The elder cinchona district, Bosque de Loja, was the source of the first barks taken to Europe. It extends from 2° to 5° south, to the boundary-line of Peru, and covers the western slope of the Cordilleras below the timber-line. This district has been worked constantly for over two hundred years, and the quantity of bark it furnishes to the Guayaquil market has fallen off in recent years.

At Pueblo Nuevo, mules and servants were engaged for the journey to the mountains. Wheeled vehicles are useless, for want of roads, and all transportation is done on the backs of beasts or Indians. Before reaching the highlands, forests of ivory-nut palms with their long, graceful, feather-like branches, and scattered trees of *Cinchona magnifolia*, a valueless species, are met with. Occasionally we found clearings, with extensive *haciendas* of cacao, coffee, sugar-cane, and anatto. The farther we got into the higher mountains, the more the difficulties and dangers increased, and at last a point was reached where the mules had to be abandoned, and, after continually ascending and descending steep places, a point on one of the great spurs was reached, whence was seen an undulating sea of wilderness as far as the eye could reach—a gorgeous expanse of matted verdure; here and there tall, slender columns of gigantic palms pierced the forest-roof, and gracefully waved aloft their drooping branches and leaves; and now and then a huge bank of clouds drifted up, like a Newfoundland fog, curtaining the grand scene for a few moments, and then quickly passing off. Our *cascarillero* soon descried some cinchonas in the distance by their glistening leaves, which reflected brightly the vertical rays of the sun.

This characteristic reflex of the foliage, with the bright, roseate tints of the flowers, and in some species also of the leaves, affords the means of discovering the cinchonas among the mass of the forest giants. The glossy leaf of the India-rubber tree is easily mistaken for the cinchona, but skilled cascarilleros are usually able to distinguish, at a great distance, varieties by the color of the flowers and general appearance of the tree.

At the bottom of a ravine we followed a small stream, till suddenly our guide shouted, "Cascarilla!" and we were gladdened by the sight of a number of fair-sized trees of *Cinchona succirubra.*

The cinchonas seek the most secluded and inaccessible depths of the forests; they are rarely grouped in large numbers or close together, but are distributed in more or less irregular, scattering patches. The older trees are grand and handsome, forty to eighty feet in height, trunks straight, branches regular, leaves evergreen (six to ten inches long), of a dark-green color, sometimes tinged with crimson, the upper surface of an almost waxy luster, flowers in terminal panicles of bright rose-tint and of an agreeable fragrance. The bark of the large trees is usually completely covered with mosses of the most delicate, lace-like texture, interspersed with lustrous, variegated lichens and diminutive, trailing ferns, while air-plants and vines in profusion entwine themselves among the branches of the trees, and hang in graceful festoons, forming hammocks, in which clusters an abundance of parasitic growth, particularly of the orchid family. Vegetable growths develop with wonderful luxuriance beneath the interlacing branches, which permit but little access of sunlight underneath. Everything is saturated and dripping with moisture; the very air we breathed seemed a clammy, aromatic vapor. In these vast forests atmospheric changes are continuous and abrupt; drifting banks of gloomy clouds are followed by glaring sunshine, and then tempestuous showers—all in rapid succession. The temperature is more even, averaging about 65° Fahr., seldom exceeding 80° or falling below 45°, the altitude being about six thousand feet.

To discover cinchona-tree patches in the forests, the cascarilleros ascend such high spurs as command a good view of the surrounding valleys and mountain-slopes. After discovering a forest that indicates sufficient value to render it profitable to work, a certain limit of forest-land is condemned and a claim made to the Government; upon the payment of a certain fee, a title is granted on very much the same plan as those upon mining claims in the United States. The next step of the cascarillero is to apply to a bark-dealer for funds with which to work the claim: if he can present satisfactory evidence that his forest is a profitable one, sufficient money is usually advanced, the merchant holding the title as security, with an agreement that the bark shall be delivered and sold to him exclusively; sometimes the dealers purchase claims outright, and employ men to work them. For many years the bark-trade of Bolivia was monopolized by the Government; the cascarilleros were obliged to sell their bark to a bank established for the purpose, and receive for it whatever price the officials chose to pay. This system was conducted with such flagrant injustice and dishonesty that it was finally broken up. Now, each republic levies a duty on all barks exported.

The season for bark-gathering begins about the 1st of August (in some forests as early as June), and lasts till October or November; during these months the bark cleaves most readily, and, on account of less rainfall, the forest is more accessible. It is next to impossible to enter it during the wet season. A master cascarillero with his gang (sometimes several hundred peons) establishes a main camp in the forest, on an elevated point where there is an opening in the forest, so as to allow the bark as much exposure as possible. The peons are formed into squads, and scatter through the forest, establishing small camps. When they are ready for work, and the bark-gathering begins, one or two from each division seek out the trees, while others cut down and peel them. The trees are first decorticated from the ground up as far as can be reached, and then, after felling and removing the clinging vines and mosses, the rough, outer bark is beaten off with a club or mallet. The bark is then cut around the trunk in sections of two to three feet, and longitudinally in strips of six to eight inches in width, then removed with the blade of a *machete*.

When first taken from the tree the inner surface of cinchona-bark shows a handsome cream-tint, but, on exposure to the atmosphere, rapidly darkens to a dirty red. The barks are usually taken to the main camp for drying and storage. The thick bark of the trunk requires great care in drying, because of the excessive dampness of the atmosphere, which sometimes necessitates the use of artificial heat to prevent molding; it is piled up in tiers with sticks between the layers to allow free circulation of air, and heavy stones or fragments of rocks are placed on top to flatten it. The thin bark from the young trees and small limbs dries more rapidly, and rolls itself up into quills.

One of the greatest difficulties connected so far with the gathering of cinchona-bark is that of transporting it to the coast at the end of the season. It is roughly sorted, mainly according to the part of the tree from which it is obtained, and packed in bales of about one hundred and fifty pounds each; the Indians carry these bales on their backs a distance of sometimes hundreds of miles to a transfer warehouse, whence it can be transported by mules to the nearest shipping-place. The worn appearance of most flat bark of commerce is due to the long friction which it undergoes during transportation.

The Indians, in carrying bark, bear the main weight of the burden upon their heads, by placing over the forehead a strip of rawhide to which are attached cords of the same material lashed to the bale; they stoop forward to maintain their equilibrium, and use long Alpine sticks to steady and aid them in ascending or descending dangerous cliffs. The skeletons of hundreds of wretched peons can be seen in the far depths of the chasms below of some of the older trails, bleaching beneath the tropical sun, whose earthly toils were ended by a misstep on the verge of one or the other frightful precipice, and now and then ghastly human skulls are seen placed in niches or crevices in the projecting rocks of the mountain-sides along the narrow passage, suggestive of lurking dangers. Another fearful terror to the Indians is the malarial fevers, to which they quickly yield, owing to great exposure and want of nutritious food. It was said that, during a recent severe malarial season, as many as twenty-five per cent. of the Indians employed in one district died from fevers before the harvest was completed, and it is only by extreme poverty, or obligations as peons, that they are induced to enter the bark forests to encounter the dangers for the meager pittance of ten to twenty-five cents per day.

The final sorting and classifying of bark are done at the main store-houses at the coast, where it is closely packed in ceroons of previously moistened cowhides (hair-side out), or in bales of heavy sacking. There it is that most of the adulteration is done. The admixture of inferior barks with higher grades is not so much the result of ignorance as sometimes supposed, for the bark-dealers are generally very expert in determining the different varieties and estimating the values of barks. Yet, strange to say, very few bark-merchants ever become wealthy.

All barks enter the market bearing certain brands; these brands used to gain a reputation according to the quality of bark they represent, but frequent occurrence of sophistication of reputed brands with inferior grades of bark has brought on the result that large buyers do not any more purchase cinchona-barks without first making careful assays, but even with this precaution they are sometimes deceived, on account of the adroit manner in which the barks are mixed.

The points of shipment for Ecuadorian barks are Guayaquil and Esmeraldes; for the barks of northern Peru, Payta; from southern Peru and Bolivia, Arica, Islay, Iquiqui, and Callao. A limited quantity of Bolivian bark is exported by way of the Amazon to Para. The greater portion of the bark produced in the northern and eastern districts of the United States of Colombia reaches the market by way of Carthagena and Baranquilla on the Caribbean coast, but that collected in the state of New Granada is mostly shipped from Buenaventura on the Pacific coast. Venezuela furnishes very little bark, and that is sent from Puerto Cabello.

As regards the prospects for future supplies of cinchona-barks from the native forests of South America, the outlook is exceedingly discouraging; the greatly increased use of cinchona alkaloids during the last few years, with the consequent demand for larger supplies of bark, has caused a very thorough working of the old forests, and energetic seeking for new ones. The discoveries of paying forests are becoming more and more rare every year, and the new forests are found at greater distances from the shipping ports, and are more difficult of access.

The tract of country yielding the cinchona is not so unlimited as some writers would lead us to believe, nor is the supply inexhaustible; it is a fact recognized by natives and dealers, who are well informed about the extent and resources of the cinchona-bearing districts, that if the present ruinous system of destroying the trees is continued, and no effort made to propagate new growths, they will, before many years, be practically exterminated from their native soil.

With the abundance of seeds yielded by the cinchonas, one would naturally expect young plants to spring up in great numbers, but such is not the case; the light-winged seeds mostly fall upon and adhere to the ever-moist foliage, where they quickly germinate and decay; or, if, perchance, they fall to the ground, it is exceedingly difficult to gain a rooting, as the soil is covered to a depth of ten to twenty inches with loose, decaying leaves. Beyond all doubt, the cinchonas might be successfully cultivated in their native country, especially in the exhausted forests; but the natives show no enterprise, and foreigners receive no encouragement from the governments to attempt it. Two Germans have recently made a venture at cultivating cinchonas near the city of La Paz, Bolivia, but as yet the plants are not sufficiently developed to determine the results.

The almost continuous revolutions and wars in those South American countries so unsettle everything as to render investments hazardous; the roads and ports are sometimes blockaded for months, preventing the importation of goods or shipment of barks, often entailing heavy losses upon the dealers.

In case of war or revolution, every Indian peon is subject to military duty, and, if required, is forced to enter the army; sometimes it is impossible to obtain sufficient cascarilleros to make it pay to enter the forests; hence it is that political troubles in those countries so greatly influence the price of bark and quinine.

The efforts of the Dutch and British Governments in taking energetic and extensive measures, by establishing vast plantations of cinchona-trees in their eastern colonies, to insure against the possibility of the world's bark-supply becoming exhausted, are therefore of paramount importance; and it is a matter of general concern and gratification that their experiments are proving from year to year more successful, yielding an excellent, ever-increasing supply of bark, mostly rich in valuable cinchona alkaloids.

TYPES OF THE NUBIAN RACE.

PROFESSOR A. KIRCHHOFF has published, in the "Transactions of the Geographical Society of Halle," an interesting description of a party of Nubians who came to that city with the caravan of Messrs. Rice and Hagenbeck. The traveler Marno, in his "Journey into the Egyptian Equatorial Provinces and in Kordofan," gives a flattering account of the handsome forms and features of the youth of the nomadic people of those provinces, with the faces of the boys so fine and soft that one might be made to doubt whether they may not be girls. These handsome traits disappear as the youth grow older, and give way to repulsive ones, especially among the women. One of the most striking peculiarities among the men of the Bishareen and Hadendoah is their manner of wearing the hair. After being worked up into a great tuft on top of the head, it is smeared as thickly as possible with tallow, which, melting under the warmth of the sun, flows down over the face and the back of the neck, and anoints them well. This account, although it relates especially to the pastoral races, whose range extends from the northern boundary of Abyssinia and the Nile to the Red Sea, is equally applicable to the tribes of southeastern Nubia. The twelve individuals attached to the Rice-Hagenbeck caravan, from the tribe of Beni Amr, in the southeast, afford a pleasant exemplification of the characteristics noticed by Marno. The illustrations are faithful portraits of members

Adam nod Edris. Hamid nod Mohammed.
(From Photographs.)

of the party, and give truthful representations of their forms, attitudes, and expressions. They convey no suggestion that these Nubians belong to the negro race, but show, instead, noble features, without flattening of the nose or exaggerated prominence of the jaws. The gentle prognathism and full lips of the figures remind us of the ancient Egyptain profile, the nose of the Semitic type. Their dark-brown skin does not disturb the pleasant impression which their figures make, but gives to their well-built, slender, elastic forms, with their graceful bearing, an appearance like that of bronze statues, especially when they are lighted up by the sun. The eyes of the Nubians at Halle were, without exception, dark brown, with a beaming glance, the whites mottled with yellow or brown. They all wore their lusterless black hair after the fashion common everywhere in the Bêdsha, with the top hair done up over the head in the form of a pillow, the rest of the hair twisted into loose tufts hanging downward over the ears, and gathered at the bottom into broad curls. They all had a growth of beard, not very thick in any of them, but much stronger than it is generally supposed that they have, and much like that of the south Arabians. Little or no hair grew on other parts of the body, except that they had some strong black hairs below the knees. Their height varied from five feet three and three quarter inches to five feet ten and three quarter inches, the girth of their calves from eleven and one half inches to fourteen and one quarter inches, giving an average height of five feet six inches, and an average measurement of nearly twelve and three quarter inches around the calf. The form of their skulls fixed their place among the mesocephalic races, and, with the broad facial index of seventy degrees and a small per cent., gave to the face the shape of a "well-formed oval of moderate breadth." The head rested on a moderately short, strong neck, and the muscular development of the neck, breast, and arms was very fine. Except in the palms of their hands and the soles of their feet, they appeared to be deeply colored, especially in the covered parts of the body; but the brown in the face was a little more inclined to a bronze color. The membranous skin in the corners of the eyes and on the lips participated in this coloration, and this made the splendidly preserved teeth appear all of a brighter white. The ring-finger in all extended beyond the forefinger, and the great-toe was shorter than the second toe. Their mother-tongue was the ancient Bedanîe, the Bêdsha language, but they also spoke Arabic. Their senses of hearing, smell, and sight were delicate and sharp. No trace of color-blindness could be found among them. They distinguished with ease fifteen colors, several of which were very nearly related, but had no particular terms for yellow, or to distinguish between blue and green. This fact contradicts the theory that the absence of a particular name for a color indicates a destitution of the faculty of recognizing it among other colors. For colors for which they had no specific name they used the word *sotâi*—colored.

In a like manner, says Kirchhoff, the Djâlin in adopting the Arabic language use the Arabic word *achder* (green) also for blue, and the written Arabic *assek*, blue, more in the sense of black and brown. This may throw some light on the meaning of *Bahr-el-Assek*, which we translate Blue Nile, after the meaning of the written Arabic word, when it might be better to follow the local meaning, and call it dark

Nile, in distinction from the *Abiad*, or clear Nile. Kirchhoff believes that the race-kindred of these people are to be found among the dark-brown tribes of eastern Egypt and Abyssinia, and the Hamitic branch of the Caucasian race, and maintains that they ought to be considered as a people of some cultivation. They all squatted on their heels when they sat down. It was interesting to notice how, when they sewed, they threw the cloth over the left knee, and held it fast between the first and second toes of their right foot. They spent the day in a round of sleeping, smoking, talking, and strumming upon their five-stringed (otherwise very primitive) guitars, alternating these idle occupations with the important daily business of dressing their

Mohammed nod Ali (Profile and Front View). (From Photographs.)

hair. They did not put fresh tallow upon their stately head-dress every day, but they performed punctually for each other the mutual service of arranging the cushion, using the wooden pin a foot long, with which it was fastened, as the instrument. The looking-glass was used industriously, for the inner eyelids could not be painted without it. They cleansed their teeth regularly with a short light stick of the arâk-plant, which they had brought with them from home for the purpose. Beyond this they washed themselves but little. Each one carried his "Allah" on his upper arm, a small casket inclosing a text from the Koran as an amulet. Their feet were protected with sandals, while their heads were uncovered, and they wore a small silver ring in the lobe of their right ears, and a chain of colored pearls on their necks. A belt containing the dagger was worn over their white dress, which they knew how to draw around them with considerable artistic grace.

ALGEBRAS, SPACES, LOGICS.

AN UNTECHNICAL ILLUSTRATION OF DEVELOPMENT IN PURE SCIENCE.

By GEORGE BRUCE HALSTED, A.M., Ph.D.

WHEN at the making of a new university a lot of specialists were thrown together, I was impressed by their lack of information in regard to the progress of the eldest of the family of sciences, mathematics. One fellow, a graduate of the University of Virginia, said that, from what had been taught him, he had come to believe mathematics finished by Newton, and now he was puzzled by a talk of progress. Another, an engineer thoroughly grounded in what the previous one had considered all possible mathematic, asked what it could mean—this turning out of new algebras, this new geometrizing? He had heard that metaphysics was interminable, and knew that a pseudo-philosopher could spin out metaphysic by the yard; was this new mathematic something of the same sort, or was it worth his looking into?—and so on. Let me, then, try to give an untechnical illustration of the fact that mathematic, though with a safe start of perhaps a thousand years over the other sciences, may now lay claim to be more than ever fundamentally and rapidly advancing, developing. From the vast field of choice, let us, to fix the attention, confine ourselves simply to what is involved in the addition of a single letter, *s*, to three common words, algebra, space, logic; that is, implied in getting a plural to the ideas embodied in these words.

Algebra has been and still is defined as universal arithmetic, and is most commonly thought of as simply a generalized statement of the truths about natural numbers. And historically such it was; as such it started, and was indeed a very gradual growth. In the first known treatise on the subject by Diophantus, in the third or fourth century, the few symbols employed are mere abbreviations for ordinary words. The Arabians, who obtained their algebra from the Hindoos, did little or nothing toward its extension, though it retains in its name an Arabic touch, and the word *algorithm*, always, and now more than ever, associated with it, has the Arabic *al*. It was after their treatises had been carried into Italy by a merchant of Pisa, about 1200, that important improvements began. About 1500 the first problem of the third degree is said to have been solved. After that, Cardan first gave the general solution of a cubic equation, and employed letters to denote the unknown quantities, the given ones being still mere numbers. Toward the middle of the sixteenth century algebra was introduced into Germany, France, and England, by Stifel, Peletarius, and Robert Recorde, respectively. Recorde endowed it with the symbol of relation $=$, and Stifel with the far more important symbols of operation,

+, –, √. In the same century Vieta introduced letters as symbols for known as well as for unknown quantities, and by this great advance not only laid the foundation for the general theory of equations, but rendered possible the birth of new algebras, children of the first.

The next step, a vast one, was definitely accomplished, when, in 1637, Descartes published his "Coördinate Geometry," involving an algebra of form. Sprouting from a numerical stem, this soon transcends merely metrical limits with a beautiful power of giving demonstrations projective, positional, descriptive. It matters not whether you prefer to think of this as a new algebra or as a new application of the first algebra of natural number. But, if you take the second opinion, you should know that you do so because the child is almost identical with the parent in formal algorithm. And there is a word coming into general use in pure science, yet whose present meaning is scarcely to be gained from dictionaries. It is an interesting word both in its birth and growth. When the Greek learning passed to the Arabs, so did the word ἀριθμός, as it has come to us in arithmetic. When the Arab and Moorish learning passed into Europe, the *al* was confounded with the following word, and from the Spaniards came the *g* between them. Thus, when the Indian numerals were introduced, this word came with them, and the new figures were denominated (by Chaucer, for example) *augrime* (or algorithm) figures; and rightly enough as being used according to an algorithm, for the old mathematical dictionaries give it in probably its real imported sense, as meaning the great rules of arithmetic. So Johnson in his old dictionary gives *algorithm*, or *algorism*, as the six operations of arithmetic; and the "Edinburgh Encyclopædia" has it as the rules of arithmetic, or the art of computing in some special way, and, finally, as the principles and notation of any calculus. Here we see it has sprouted and come very nearly into its present acceptation, in which I would define it as the fundamental operations of an algebra with their assumed laws and notation. In the algebra of natural number there are seven such, for we put in one more since the days of Samuel Johnson. As illustrations of simplicity and seeming insignificance, let me call your attention a moment to the three direct operations, which you have always known.

Suppose in counting we make a mark for each thing and connect them by Stifel's sign of addition, $1+1+1 \ldots\ldots +1$. Then, if we go over them one, by one we have a mark to register our result. But, even without taking the trouble to count them, we can say they will amount to some number and call it "a." But suppose we have to count a lot of the same sort of rows all equal, we know that an actual count will give for each the same number which we have called "a," and we will get a as many times as we have rows; that is, a number of times, say b times, and the grand total will be a taken b times, or ab. But suppose the number of rows should be equal to the number of columns, then we would have a times a, or $a\,a$; and in the same way we might have a times $a\,a$, or $a\,a\,a$, etc. But why write all the a's? Put one and a number above to right to tell how many, call the number b, and we have a^b.

These are the three direct operations, seemingly mere devices to spare a little trouble. You could hardly believe the conquest of the thought-world was lying dormant in them. Yet their undoing or inversion leads to the four inverse operations, and the seven, together with their working laws, are the algorithm of your algebra. So are they also of Descartes's application of algebra to form, and even Newton's fluxional calculus to a certain extent presupposes them, so that it was looked upon rather as an extension, a generalization, than as a new algebra of infinitesimals formulating its own working algorithm.

Therefore, much as we prefer Newton's character, and believe in his prior invention of the calculus, it is to Leibnitz that we assign the high honor first to have grasped the plural whose growth we are illustrating. After two of the most extraordinary of modern algebras were discovered and published, it was found that the possibility of each had been indicated by Leibnitz more than a century and a half before.

Toward the modern deep study of the formal laws involved in a pure science, Lagrange and Laplace led on also by the conclusion that theorems proved to be true for symbols representing numbers are also true for all symbols subject to the same laws of combination. Hence followed the principle of the separation of symbols of operation from those of quantity, with the "calculus of operations." The world of mind had now developed sufficiently to appreciate the definition of *an* algebra, though when it was first given I do not know. An algebra is an abstract science or calculus of symbols combining according to defined laws. There may be an indefinitely large number of sets of such defined laws—that is, of distinct, different, and independent algebras.

In the history of science it is a worthy illustration of the rhythmic character of great advance that, as if by an irruption of genius, the same year (1844) published three of the most fundamentally new and interesting modern algebras, and stamped for immortality the names of Rowan Hamilton, Hermann Grassmann, and George Boole.

Among the first men to systematically consider symbols combining according to laws more complicated than those of natural number was Sir Rowan Hamilton. After a struggle of ten years from 1833, his genius enabled him to escape from the rut of common thought by casting away the commutative principle in multiplication, which in numbers formulates the fact that twice three gives precisely the same result as thrice two. So, in 1843, he presented to the Irish Academy the principles of the algebra of quaternions, and published an article on the subject in the "Philosophical Magazine" in 1844. At the same time had appeared in Germany Grassmann's "Ausdehnungslehre," a more extraordinary algebra, which contains quaternions as a special case. But let me pause here. We have sufficiently shown our plural without even mentioning Cayley and Sylvester's invariantive algebra; Riemann's theory of a complex variable; the algebra of polar elements; or any of the many others that have sprung or are springing into being.

As for pluralizing the idea of space, that would follow very briefly if only I might talk in terms of the "Ausdehnungslehre." Quaternions, as Professor Tait has said, is content with one flat space; but Grassmann, in a little appendix of only two pages, has shown the ability of his extensive algebra to cope with the modern double plural of the old idea of space. Before this idea had germinated, while therefore there was no real use for the word "spaces," the parsimony of language applied it to mean *pieces of space;* but in the fullness of time it has received its heritage, and by spaces I mean an aggregate of which the space hypothetically infinite and containing the material universe is but one. A statement in the technical terms of analysis would probably tend very little toward clearing up this matter to one not already familiar with it. Let us, then, use rather the historical method—attack in the light of history.

As an eternal treasure and model to the world the Greeks bequeathed the synthetic science of a space. This is the particular space in which you believe, and are sure you and the stars are inhabiting. You will be glad to know that it has been made a fitting monument to the writer of the greatest classic, and inscribed with the name of Euclid. This Euclidean space is a tridimensional homaloid, and so, in distinction from it, spaces with positive or negative curvature are called non-Euclidean.

Through all the centuries up to the present Euclid's space contained at least the thought-world. The space analyzed in Euclid's "Elements" was supposed to be the only possible form, the only non-contradictory sort of space. And, after more than twenty centuries, it is to a little point in that same book that the new idea attaches itself and sprouts into being. This slender link is one of Euclid's postulates, misplaced in the English editions as the twelfth axiom. As the last of his six *αἰτήματα* (requests) Euclid says: "Let it be granted that if a straight line meet two other straight lines, so as to make the two interior angles on the same side of it, taken together, less than two right angles, these straight lines being continually produced shall at length meet upon that side on which are the angles, which are together less than two right angles." This somewhat complicated so-called axiom is only the converse or inverse of proposition seventeen, that "any two angles of a triangle are together less than two right angles," a theorem readily demonstrated from the preceding postulates and axioms. An inverse is usually exceedingly easy to prove. Then why not remove this inverse from among the postulates, place it after seventeen, and demonstrate it? This obvious way to improve on Euclid suggested itself to numerous geometers throughout the centuries. Hundreds tried it, and failed. As in squaring the circle, some claimed to have accomplished it; but against each one all the rest decided.

It now seems queer that no one during all this time systematically developed the results obtainable when this postulate is denied, is negatived, is thrown overboard. Euclid's method, the *reductio ad absurdum*, would have led them on to this if only it had ever entered their heads to suspect a plural to space. But the perfect originality of this step required genius, and has given a permanent rank in the history of science to two names of which otherwise we should probably never have heard, Bolyai and Lobatchewsky. Their publication of a non-Euclidean geometry gave the entire question a totally new aspect, and from that moment everything previously printed on the subject became antiquated; everything else became moribund, and the world of geometries was dualized into Euclid and non-Euclid. Like Columbus, they discovered and opened a new continent, into which for the last forty years geometers have been swarming, rewarded by many gold-mines. On non-Euclidean spaces and the kindred subject, hyper-spaces, I have given in the "American Journal of Mathematics" a list of about one hundred and eighty publications since 1844. In dividing spaces with reference to the parallel-postulate, those in which through one point outside of a straight line can be drawn more than one parallel to that line are called hyperbolic spaces; that space in which through the point we can draw one and only one parallel is called parabolic; those spaces in which we can draw no parallel straight lines are called elliptic. In hyperbolic spaces the sum of the three angles of any triangle is less than two right angles, in parabolic equal to, in elliptic greater than, two right angles. Elliptic spaces are positively curved spaces, hyperbolic are negatively curved spaces, while the parabolic has no curvature, is a flat or homaloidal space.

This pluralization of the idea of space is independent of dimensionality and came synthetically. But about the same time came analytically a plural having reference to dimensions. Our perceptions, intuitions, imagings, are confined to a flat space of three dimensions, and this gives us a strong prejudice in favor of the belief that our bodies and the stars are also confined in a tridimensional homaloid. But this is simply a question of fact in the domain of physical experimentation.

How this belief might be negatived is easily illustrated. In 1872 Clifford said before the British Association: "Suppose that three points are taken in space, distant from one another as far as the sun from α Centauri, and that the shortest distances between these points are drawn so as to form a triangle. And suppose the angles of this triangle to be very accurately measured and added together: this can at present be done so accurately that the error shall certainly be less than one minute, less therefore than the five-thousandth part of a right angle. Then I do not know that the difference of the sum of the three angles of this triangle from two right angles would be less than ten degrees, or the ninth part of a right angle." This says that it is within the power of our astronomers to discover that our space is not flat. And already spiritualists claim to have experimentally demonstrated that our space has more than three dimensions. As for myself, I admit I am prejudiced just as you are. I do not think it probable that astronomers will prove that we are living in a curved space, and everything connected with spiritualism seems to me disgusting bosh. But it is not the probability that I want. I am simply illustrating the possibility, and this is enough to bring the matter into the domain of simple external reality.

You have the meaning of a fourth dimension strikingly put before you every time you look into a mirror. There you see yourself so turned around that your right hand has become your left. If you were to step straight out of the looking-glass every one would think you left-handed. Such a change could be accomplished by revolving you in the fourth dimension, and in no other way. Therefore a mirror will show you at any moment exactly the effect of a fourth dimension. Then why is this not a proof of the actual existence of a fourth dimension? I answer that here, as in the case of the spiritualists, there is deception.

It would be proof if there were no deception. The straight rays of light break against the mirror and are turned back. Our eyes give us no account of this break and turn, and so deceive us, putting before us, like the spiritualists, the effect of a fourth dimension. These are not questions which can be decided by reference to our space intuitions, for our intuitions are confined to Euclidean space, and even there are insufficient, approximative. For instance, you suppose you can imagine a curve on a plane, and so in physics curves are taken to represent functions. In reality you can not get any closer to it than what the Germans call a stripe. The analytical copy of the curve is not the function but the stripe.

But you may say, How can we ever go better and deeper than our intuitions? If I answer, "Logic," you are apt to feel soothed. It is wonderful what a strong though often unconscious distinction exists in the general English-speaking mind between logic and metaphysics. Metaphysics is always scorned and scouted; but if you say logic, ah! that is a very different matter. Again, I must acknowledge for myself sympathy with the general feeling. I think most metaphysics ought to be scorned; and I am glad that in English logic means formal logic, a pure science, and is rarely mixed up with a metaphysical Erkentnisslehre or *ken-lore.* To be sure, formal logic was for ages the most fixed of all things, and so fell into some disrepute, since to be stationary and unprogressive is to be so far unscientific. But at last came the awakening. In 1847 two mathematicians, Boole and De Morgan, published works on logic. Thenceforth was no longer applicable the latter's reproach: "First, logic is the only science which has made no progress since the revival of letters; secondly, logic is the only science which has produced no growth of symbols." Among De Morgan's many gifts to advancement, perhaps we should select as most important his founding a logic of relatives. But even he thought Boole's calculus of inference the most extraordinary advance ever made in logic. At a single stroke of genius, unheralded, sprang forth an algebra of logic. This stroke shattered the imprisoning magic circle of Aristotle; and in the last few years four or five new algebras of logic, differing more or less from Boole's, have come into being; another is now being published, and I know of two more preparing. I will not attempt here any explanation or eulogy of what has been thus accomplished for logic. This can already be found in English, French, and German. Modern logic will date from Boole.

But I wish to call attention to the fact that here we find the best, the most satisfactory introduction to the study of modern algebras, modern mathematics. When told that in these systems a product may not vary with each of its factors; that a product may vanish without either of its factors vanishing; that subtraction and division may be indefinite; that, in fact, any system, e. g., quaternions, where the products and powers of the units are themselves linear functions of the units, excludes the ordinary assumption that a product shall vary with each of its factors; that from $q q_{,} = 0$, it does not follow that either $q = 0$ or $q_{,} = 0$; that a quadratic equation, e. g., in quaternions, besides its sixteen roots proper, may have an indefinite number of roots which arise from the fact that the process of division is not a definite one; when told these, and very many more such, the beginner is only too sure to think, "This is a hard saying," and may give up the subject in hopeless confusion. If, however, he will start with Schroeder, "Der Operationskreis des Logikkalkuls," he will find the clearest explanation and illustration of these things contained in his own every-day thoughts about the commonest objects; and, while learning an elegant logic, will be mastering, perhaps, the most exquisite dual algebra.

CHEMICAL EXERCISES FOR ORDINARY SCHOOLS.

By ELIZA A. YOUMANS.

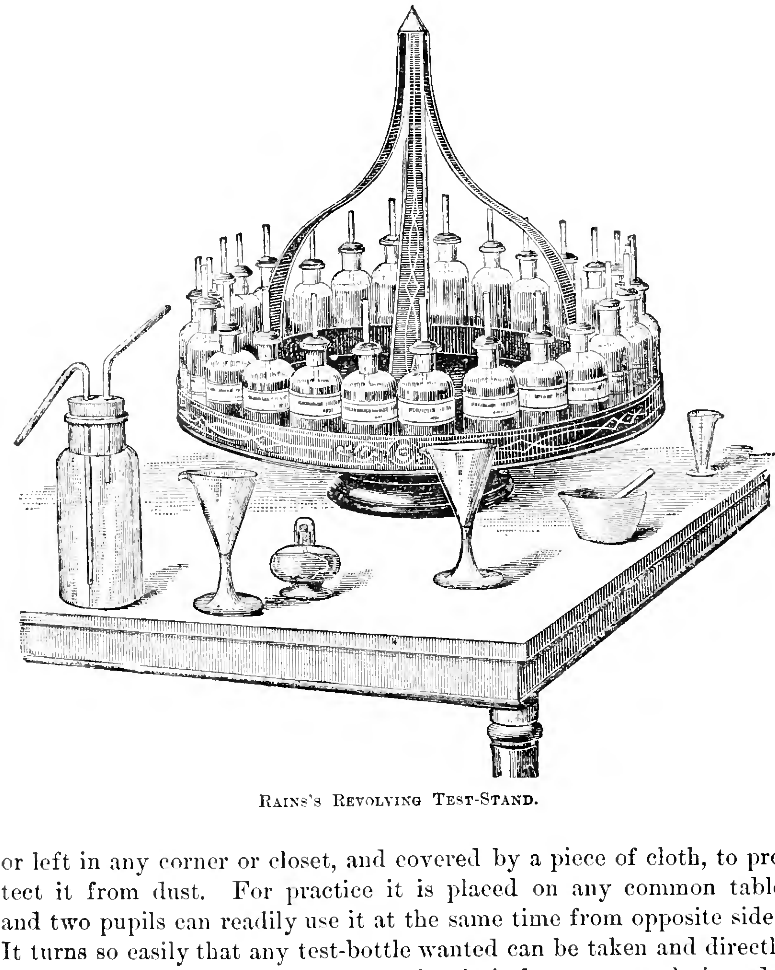
PROFESSOR RAINS'S little book for beginners in analytical chemistry has been already noticed and commended in these pages, but its method is so excellent that it needs to be more fully explained.

Chemistry is now a regular study in many if not in most schools;

but, in the common mode of pursuing it, the pupil gets but very little real knowledge of the subject. He reads about it; learns lessons upon it; works out chemical calculations for examination; and, perhaps, sees some lecture-room experiments. He acquires some general ideas, but he gets very little actual, thorough, practical knowledge of the properties of chemical substances, and no such familiarity with chemical operations as is necessary in order to turn this branch of study to valuable account. Professor Rains saw that all this was unsatisfactory; and that, to make his knowledge good for anything, the pupil must experiment, must test the properties of substances, and himself find out how they behave and react toward each other. In short, if he has any honest, intelligent, educational purpose in view, he can only gain it by practice and direct experience with chemical agents and materials.

But there is a difficulty at the outset met everywhere, and which is generally fatal to all thorough chemical study in ordinary schools. Practical chemistry is dirty work. It makes slops and fumes, and damages furniture and clothing, and, as has been graphically said, it is altogether an unsavory affair of "messes and stenches." With such a reputation it is, of course, held to be unsuited to the schoolroom, which indulges no further in dirt than is compelled by the use of chalk and the blackboard. In this respect school habits are established. Practical chemistry must, therefore, have its separate place, its laboratory, which is a shop and not a schoolroom. Chemistry involving "exercises," or manipulations in object-study, is therefore expelled from the schoolroom to a place fitted up for it, so that chemistry in ordinary schools is a matter of book-learning and second-hand information, such as is now correctly characterized as "sham knowledge."

Professor Rains has addressed himself to this difficulty, which he aims to overcome so effectually that practical chemistry may be pursued almost anywhere with but very little inconvenience. He saw that this is the first and indispensable step to success in making chemistry a real branch of common education; and he accordingly set himself to contrive a little compact, portable laboratory, such as can be readily used anywhere, and would at the same time prove adequate for the uses of the student. And he has well succeeded in his object. The accompanying woodcut represents his device. It consists of a revolving test-stand, twenty or twenty-four inches in diameter, made of galvanized iron or strong tin-plate, so as to hold a large number of test-bottles, containing the reagents for analysis. These bottles stand side by side, and are kept in position by an outside and inside rim, soldered to the circular plate. There is a hole in the center of this plate, and a tube, fifteen inches long, has its lower end soldered above it, the upper end being closed. An iron rod, screwed into a stand or base, and conical at the top, passes up through the tube and supports the whole upon its point. To stiffen the arrangement, three bent strips of tin are fastened to the top of the tube and to the inner rim, as shown in the woodcut, where the middle strip conceals the central tube. There is room inside the circle of test-bottles to place the other bits of apparatus when not in use. The whole construction occupies but a small space, and can be conveniently set aside when not required,



RAINS'S REVOLVING TEST-STAND.

or left in any corner or closet, and covered by a piece of cloth, to protect it from dust. For practice it is placed on any common table, and two pupils can readily use it at the same time from opposite sides. It turns so easily that any test-bottle wanted can be taken and directly returned to its numbered place, so that it is kept constantly in order for continued exercises.

It must not be supposed that this is merely a nice plaything to enable boys and girls to make amusing chemical experiments. Professor Rains had a very serious purpose in preparing it; and it is designed for systematic chemical work. It has been adapted to take pupils through a course of qualitative chemical analysis. Besides the necessary apparatus, there is a sufficient equipment of test-substances for going through a full course of analytical exercises. At the very outset the pupil begins to *think*, and has to make his own way. He learns the properties of chemical bodies by trial and observation; and his progress consists in solving a succession of problems by finding out and identifying chemical elements and compounds. Some seventy or more simple salts soluble in water are the substances chosen for examination, and these are first tested to find the base or metallic component of the salt, and then to find the acid or electro-negative element. It is a work of investigation from the start, and what the pupil learns he *knows*. There are no recitations, the evidence of proficiency being what the pupil can *do*. The course is one of self-instruction, and its value depends upon the principle that one difficulty overcome by the pupil himself is of more educational benefit than a score of difficulties over which he is helped by others. Professor Rains's little accompanying manual begins by explaining the use of the necessary apparatus, and then the inquirer is directed how to enter upon his regular work; but, the problems being presented in order, he is left to solve them himself, which is the only way in which he can become a chemist.

Nothing so neat, compact, and convenient as this mechanical arrangement has ever before been furnished for beginners in analytical chemistry. The method has grown out of Professor Rains's experience as a chemical teacher; and only by a long course of assiduous trials with students and classes could he have succeeded in putting into such small compass, and such a portable and convenient form, the facilities of manipulation by which a practical foundation in the knowledge of the science can be laid. In his annual course of lectures upon "Physics" and "Chemistry" at the Medical College of Augusta, Georgia, Professor Rains has among his students the senior class of Richmond Academy, an institution in which for several years he has been the teacher of Natural Science. As a result, he became convinced that a much larger amount of chemical study than is commonly supposed, and that, too, by direct chemical work, might be given to the senior classes of ordinary schools where there is no laboratory, and no specially qualified chemical teachers. He was so sure of this, and so impressed with the value of practical work in chemical analysis—the most interesting of all chemical practice—that for several years he has given the senior academy class a certain amount of chemical testing to do by themselves, furnishing them only with simple apparatus and clear directions. In this way the self-education of the pupils has gone forward with the happiest results. Satisfied that the same advantages may be secured by others, if they have only the requisite means of practice furnished to hand, he has constructed the little laboratory that will now be furnished to anybody by the instrument-maker.

As to what has been actually attained with classes by this method of study, Professor Rains thus remarks in his preface: "At the recent closing exercises of the examination of the pupils of the academy, which took place at the Opera-House before a large audience, the following were the results from the chemical class of fourteen students: Samples were taken at random from the bottles of different commercial salts (single bases and acids) by one of the trustees and given to each student. Of the fifty analyses made in a little over one hour, not a single failure was made. The class had studied theoretical chemistry for seven months three times a week, one hour's recitation each; after which they had table-practice for eight weeks, or twenty-four school-hours; to which as many more were voluntarily added by the students after school, making forty-eight hours in all of analytical work."

This brief statement is full of important suggestions. The preliminary study of theoretical chemistry for seven months, probably in the ordinary way of lesson-learning, was, no doubt, somewhat helpful; and it would be well for all pupils, in entering upon a course of exercises in analysis, to be possessed of some elementary chemical ideas. But the practical experience of actual investigation is so much a thing by itself, that those who have read up do not really have the great advantage over beginners that might be supposed. The pupil who goes to work fresh will very soon get the elementary conceptions needed, and he will then read chemistry with redoubled interest, and to better purpose.

But what is significant in this case is that, when the pupils came to practical work, they voluntarily doubled their tasks, and this, too, notwithstanding the "hardness" of exercises that had to be mastered unhelped. The mode of study was attractive because there is no pleasure like the sense of power that comes from conquest. There is, moreover, a fine satisfaction in that free play of the faculties which self-instruction implies; and Professor Rains says, "The students are allowed entire freedom while at work." The superiority of this mode of study can no longer be questioned; and Professor Rains has done a very important service to education in thus facilitating the thorough and at the same time pleasurable pursuit of one of its most useful branches.

THE EXTREME RARITY OF PREMATURE BURIALS.

By Professor WILLIAM SEE, M.D.

THE article on "Premature Burials," in the January (1880) number of this journal, from its tendency to magnify the importance of the probabilities of premature burial in cases of trance and suspended animation, and from its assertion that, in effect, the ordinary physician or general practitioner is not capable of reaching a satisfactory conclusion upon the signs of death, has led the writer to brief in what follows the opinion of the medical jurists of the present day upon this subject. That the trance state has been mistaken for death, and that premature burials have taken place, seem to be fully recognized in the system of morgues or dead-houses in various parts of Europe where bodies are so placed that the slightest movements will be brought to the notice of attendants; and in the laws which in most countries require the lapse of twenty-four hours and longer periods between death and burial. Yet competent authorities tell us that such institutions (morgues) are superfluous when ordinary care is taken by the relatives of a deceased person; and Taylor says that he has never met with any instance in which a body laid out in them was resuscitated after there had been a proper verification of death.*

In discussing this subject, how far are we justified in taking the statements of the earlier writers? The credulity of the public in similar matters is sufficiently shown in such works as Carpenter on "Mesmerism, Spiritualism," etc., and Hammond on "Fasting Girls," to induce us to view general statements with much suspicion. M. Fontenelle has published forty-six cases of premature burial from the time of Plutarch downward. Taylor, from whose work on medical jurisprudence this article draws freely, after a careful examination of all these cases, rejects the greater number of them simply because they are drawn from such sources as to render them perfectly inadmissible as evidence. M. Carré, in 1845, published the assertion that forty-six cases had occurred since 1833. Taylor examines his cases, and finds that no particulars by which their accuracy can be tested have been given. The whole subject, as taken from the tone of the article now commented upon, and from public opinion in general, resolves itself into two statements, viz.: that it is quite possible, and has been proved, that a state of trance, prolonged and of a nature to simulate death, may exist and deceive even those whose daily avocations make them familiar with death itself; and that many cases are on record where changes in the position of the body, and even where the birth of children, have taken place after interment.

For the existence of a trance state sufficient to simulate death, all appreciable movements of respiration and circulation must be suspended for a considerable length of time, and there is but one properly authenticated case on record as accepted by physiologists; even this case will not bear too close discussion at the present day. We are told in works on physiology that a Colonel Townshend was able at will to suspend animation to the extent of obliterating any perception of the heart- or pulse- beat, and of any respiratory movement, as a mirror held over the mouth and nose showed no dimness of its surface; and further,

* Forty-six thousand bodies were deposited in the mortuary institutions of Germany during a space of twenty years.

that he was able to continue in this condition for the space of half an hour: at the end of this time gradually the signs of returning vitality began to assert themselves until a perfect restoration of the functions of life ensued. From the description generally given, we are led to suppose that this was done not once but several times, and that the subject was under careful inspection by medical men during the continuance of this state. But Braid, in his "Observations on Trance," tells us that Colonel Townshend, as a patient of Dr. Cheyne, was in the last stages of a chronic kidney-disease when, *nine hours before his death*, he made known to his medical attendant his conviction of an ability to "die or expire when he pleased, and yet, by an effort or somehow, he could come to life again." This he tried before Dr. Cheyne, with the result as just recorded. This case happened nearly one hundred and fifty years ago, and, in view of its occurring only once and under such peculiar circumstances, with no details as to the extent and accuracy of the means taken to obviate all sources of error, leaves room for the skeptic, without casting a slur upon the good name and reputation of Dr. Cheyne, to express strong doubts upon its probability.

A case which has interested the medical profession very much and is of recent date, is that of the late Dr. Groux ("Proceedings of the Medical Society, County of Kings," vol. iii., p. 350, *et seq.*), in whose person there existed from birth an opening or fissure in the breastbone (sternum) which he could extend by forcible separation to the width of two inches. He was supposed to have possessed the power to arrest the action of the heart at will—for a duration of about twenty seconds—but without any other disturbance of his usual condition. The arrest of the heart's action in this case is affirmed positively by some, doubted by others; one examination by three medical gentlemen developed no stoppage of the heart's action, but merely a stoppage of the pulse at the left wrist, attributed to the unusual mobility of the collar-bone (clavicle), by which the artery (subclavian) passing under it to the wrist was compressed.

Medical jurists, after carefully examining all evidence that can be accepted upon such cases, have concluded that it is impossible to suspend animation or to simulate the same, without detection by the *ordinary* means, for so long a space of time as one hour; and it is fair to assume that when such cases are reported they are due to gross negligence, for where the medical practitioner does his duty and calls in to his aid the ordinary means as taught in all the medical schools, of listening at proper intervals and for a sufficient length of time for the heart-beat, he will find that no heart can intermit its beats—that is, remain in perfect repose—for a space of five minutes in time. Cases are cited in newly-born children where twenty minutes have been supposed to elapse after suspension of the heart's action before resuscitation took place, but these are considered as due to imperfect or careless tests.

The respiratory movements coincide generally with the heart's action: all respiration ceasing, the heart never continues to act longer than five minutes, and these movements can be noted by the non-medical observer, by placing a piece of looking-glass, or a dish filled with water or mercury, upon the chest, and allowing the light to be reflected upon the surface; the slightest movement will result in oscillations.

A common mistake of death for a supposititious trance state is the continued or increased warmth of the body, which is so remarkable in some cases; there are instances where days have elapsed before the body was allowed to be put in the ground, because of its continued warmth, and of the absence of the corpse pallor; and again it has been frequently noted in cases of death from cholera that bodies, which at the time of death were moderately cool, have developed a temperature of 87° Fahr. and of 92° Fahr., and in cases of death from injuries to the nervous system even a much higher temperature has been reached —evidences, as Taylor puts it, of some latent vital power or chemical force still lingering about the circulating system.

While the trance state is a source of mystery and wonderment to the popular mind, the positive statements of a change of position in a body, and even of the birth of children after death, are something more tangible and real, and carry their convictions in a more decided manner. Yet these phenomena in many cases are accounted for in the most natural way. There is inherent in the muscular tissue of our bodies a certain irritability or tonicity—vitality, perhaps, is a good expression —of the muscle itself, which is independent of the brain, nerves, circulation, or respiration, in that it continues to exhibit its function—that of muscular contraction—for an appreciable time after death has abolished these forces, and physiologists, by supplying the muscles with nutrition, such as the injection of defibrinated blood, have been able to excite this irritability so late as sixteen hours after death. It is this irritability which results in the *rigor mortis*, or rigidity of death, and which sets in generally within five or six hours, lasting from sixteen to twenty-four hours. With this rigidity is a muscular contraction usually not resulting in any change of position of the body; but the flexor muscles exhibit a greater tendency to contraction than the extensors, and there are instances where this contraction has been quite marked, resulting of course in a change of position. If a body be not properly laid out and placed in a coffin in the cramped position in which *rigor mortis* has set it, there will necessarily be some change of position when, at the end of the time mentioned, this condition passes off and a relaxation ensues. In one case of death from cholera, half an hour after complete cessation of circulation and respiration, the muscles of the arms underwent spontaneously various motions of contraction and relaxation, continuing for upward of an hour.

The fact of finding a dead child lying by the side of its mother in the coffin, with the knowledge that it was born or extruded after interment, must have a startling effect upon the ordinary bystanders, yet Dr. Aveling ("Obstetrical Transactions," London, 1873) has reported thirty cases where the expulsion of the child was due "either to a contracting power remaining in the uterus after the death of the rest of the body, or to the pressure exerted on the uterus by the gases of putrefaction, the latter being the more frequent cause."

The only motive in preparing this paper has been, not to contradict the fact that premature burials may have taken place and under the most unhappy circumstances, but to place renewed confidence in the ability of the *ordinary* general practitioner of medicine to recognize the distinction between a state of trance and a state of death, and to induce a disregard of the idle stories of ignorant and superstitious persons upon premature burials.

THE ST. GOTHARD TUNNEL.

THE boring of the St. Gothard Tunnel is pronounced by one of the engineers to be the greatest work hitherto attempted by man; certainly its importance and magnitude can hardly be overrated. It deserves to be regarded with especial admiration as a work which was marked in every department and at every stage by triumphs of the highest skill in scientific engineering. The tunnel is intended to form part of the railway connecting the North Sea with the Mediterranean, and is situated on the most direct route between these regions, passing through the chain of the Alps at a central point. The railroad through this line was preceded by the road over the Brenner Pass of the Tyrol, for that was easier of execution, and by that through the Mont Cenis Tunnel, for the French Government had political reasons for constructing a road which should be under its own control. The Swiss soon saw, after the rival lines were constructed, that the traffic which belonged to them would be diverted to pass around them, and immediately began operations to open a road through their own most direct route. In this they enjoyed the coöperation of Germany and Italy. The operations at St. Gothard were begun under the advantage of the possession of the experience, knowledge, and skill that had been gained in constructing the tunnel of Mont Cenis.

The preliminary surveys made it certain that the only points at which the opening of the tunnel could be made were near Goeschenen, in the Canton Uri, on the north, 1,109 metres or 3,604 feet above the sea, and near Airolo, in the Canton Tessin, on the south, 1,145 metres or 3,721 feet above the sea. Considerable works were necessary to reach these elevations. An examination of the map showed that the tunnel might be straight and that it would be about 15,000 metres or

48,750 feet long. The engineers of the tunnel of Mont Cenis had a point at the highest part of the ground from which they could see at once objects indicating the positions of both openings. No such advantage existed at St. Gothard, and some of the summits are so steep

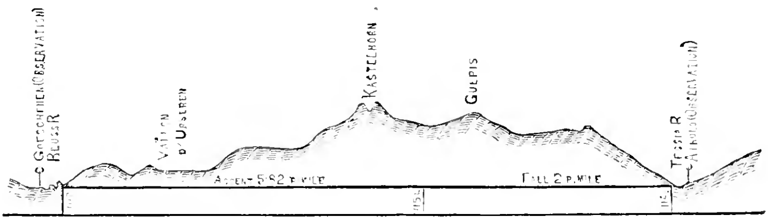


Fig. 1.—Profile along the Length of the Tunnel.

and high that it is impracticable to attempt any direct tracing of the line over the mountain. The relative position of the two openings and the direction of the tunnel had then to be calculated indirectly, from triangulations. The directions and levels were thus ascertained. Observatories were then placed at the tunnel-mouths to serve as direction-points for the miners. At Goeschenen it was necessary, in order to get a long enough line of sight, to make borings of considerable length through two projecting rocks. The surveys, originally made by M. Gelpke, were verified by a second series of triangulations made in 1874 by another engineer, M. Koppe, on a different system. M. Gelpke had based his surveys on summits in the neighborhood, and had used triangles of only moderate size. M. Koppe made his triangles as large as possible, so that he might connect the two openings of the tunnel by a minimum number of intermediary stations. The two triangulations gave results agreeing within two seconds of direction with each other. M. Koppe also verified his survey practically by projecting a line from the opening at Airolo toward a mast which he set up at the highest attainable point along the axis of the tunnel. He could not go toward this point from Goeschenen, so he went backward in the direction of the continuation of the tunnel-axis, ascending the flanks of the mountain till he could observe his mast. Then, having directed his glass toward Goeschenen, he raised it vertically to the level of the mast, when he saw it almost in the center of his field of vision. The direction within the tunnel was verified by means of field-glasses fixed within the observatories, so far as they would answer, then by means of lamps hung on the line of the axis. The direction was, moreover, carefully verified from the observatories two or three times a year.

The borings were made almost entirely by machines, and it was the policy of M. Louis Favre, the contractor for the tunnel, to dispense with hand-boring as far as possible. The machines were driven by water-power transmitted into the tunnel by means of the compressed-air apparatus of Professor Colladon, of Geneva, which had already been used at Mont Cenis. Water was obtained in great abundance and of strong fall at Goeschenen from the river Reuss. The supply of water at Airolo was not so abundant. The river (the Ticino) has not a rapid descent, and a very long canal would be required to procure a sufficient fall from it. A torrent, the Tremola, was chiefly relied upon, but the supply from this fell short at times, and had to be supplemented by an auxiliary supply from the Ticino. The force of the stream was applied to turn four turbine wheels which made three hundred revolutions in a minute, and exerted a force of about two hundred horse-power. These wheels were made to turn an horizontal axis with cranks revolving eighty-five times a minute, which kept the compressors in operation. The air, subjected to a compression of from four to eight atmospheres, became very hot, and had to be cooled by special applications of water circulating in cold currents around the pumps and in the pistons and piston-rods, and by injections of fine spray. After being further cooled and freed from water in suspension by passing it through reservoirs, it was conducted into the tunnel by tubes which were of considerable size at the beginning, but were diminished to correspond with the diminishing expenditure of air as the work was advanced.

The borings were begun by first cutting out a gallery about eight feet square at the top of the intended excavation. When this advance boring was completed, it was enlarged on the right and left. The arches of the roof were then built, and a trench nearly ten feet wide was dug to the level of the tunnel's base. This was called the "Cunette de Strosse." All that remained on the right and left of the

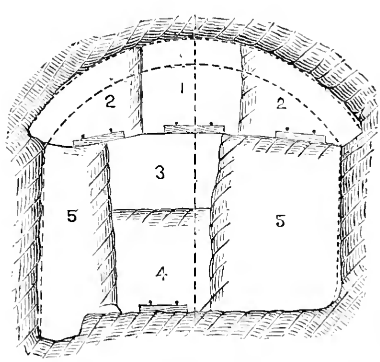


Fig. 2.—System of Excavation: 1, advance gallery; 2, side-workings; 3, 4, "Cunette de Strosse"; 5, "Strosse."

trench, called the "Strosse," was next removed. Thus, most of the digging was done downward. The work was interfered with at times by the infiltration of water, which, as it did not affect dynamite and soon stopped, was not considered serious; by rocks of exceptional hardness; and by a bed of loose material in the Goeschenen end, in which it was dangerous to work for fear the mass would fall and bury the workmen, and cut off their retreat. Communication was opened between the two galleries on the 29th of February, 1880. The chief miner on the southern (Airolo) side had pierced an horizontal hole about ten feet long, and had caused the attacks from the side of Goeschenen to be suspended on his penetrating to the northern gallery. Proceeding with a boring of moderate depth, he reduced the thickness of the remaining mass to about four feet. Preparations were made for the final attack by piercing four holes in the center of the boring, and eleven other holes at equal intervals around it and not very far distant from it. The explosion opened a passage of a little more than thirty inches in diameter, through which the engineers and some of the workmen were able to go over from one gallery to the other. When the communication was first opened, at eleven o'clock in the morning, the barometer stood .156 of an inch higher at Goeschenen than at the southern end of the tunnel. A current of air was immediately produced in the gallery, which blew at the opening at the rate of a metre and a half (nearly five feet) a second. A few hours later the relative pressure was reversed, and the barometer stood .039 of an inch lower at Goeschenen than at Airolo. The direction of the current of air was consequently changed; it blew from south to north, but at the rate of only about a foot in a second. The actual length of the tunnel was about twenty-five feet shorter than the calculated length. The difference in the level of the two galleries was not more than four inches, and their lateral deviation was not more than eight inches. According to a statement made by M. Colladon to the Academy of Sciences at Paris, the most efficacious means adopted to speed the work of excavation were the diking of the torrents and the application of water collected in aqueducts as a moving power to turbine-wheels requiring high falls, the adoption of air-compressors which worked with great rapidity, the cooling of the air in the compressors, at the moment of compression, by the injection of water in a fine spray, the use of dynamite, and the determination which was adopted from the beginning to carry on the excavations from the top of the tunnel. By the aid of these improved methods the advance through the hard rocks was made with double the speed that the engineers in charge had been able to attain in boring the Mont Cenis Tunnel. It is estimated that, notwithstanding its greater length, the tunnel of St. Gothard when completed will have cost from twenty-five to thirty per cent. less than that of Mont Cenis.

The provisions for conducting compressed air into the galleries, involving a system of pipes upward of sixteen thousand feet long in each gallery, afforded excellent opportunities for studying the flow of compressed air through metallic conduits. The loss of air in passing through the pipes was an important factor. The absolute pressure of the air, which was equivalent to six and a half atmospheres at the

Goeschenen mouth, was diminished till it became, toward the end of the work, no greater than one atmosphere and an eighth at the front of the cutting. At Airolo it was necessary to enlarge the diameter of the perforators, and a much larger volume of air had to be spent to do the same work. The temperature at the front of the excavations rose to 91° during the last days of the operations, and greatly taxed the endurance of the workmen. Calculations have been made to the effect that, taking the work all through, each kilogramme of dynamite that was used corresponded with a cubic metre of rock that was removed. Among the gains to engineering which, it is claimed, have accrued from the enterprise, are the perfection of the machinery and tools for boring, and the training of a body of skilled workmen, who have become experts, able to determine, by merely inspecting a rock, how to deal most efficiently with it. The perforation of tunnels will in the future be a simpler, easier, and less costly operation than it has been heretofore. Since communication was established between the two galleries of the tunnel, a part of the mountain mass, 6,300 metres, or 20,475 feet from the southern entrance, has fallen in, killing and injuring several of the workmen.

M. FOUQUÉ'S SANTORIN AND ITS ERUPTIONS.

M. FOUQUÉ, a professor in the College of France, has recently published an elaborate work on the volcano of Santorin, which is considered one of the most remarkable and instructive examples of volcanic phenomena on the earth. He possesses excellent qualifications for this work, for he has made special researches on the volcano on three different occasions: first, when sent by the French Academy of Sciences in 1866; and twice afterward, in 1867 and 1875, under a commission from the Minister of Public Instruction. His account embraces the detailed recital of the observations which he made on the ground, and the description of his labors in the laboratory, analyses, and microscopic examinations, and contributes much to our knowledge on mooted questions respecting volcanic action.

The products thrown out in the recent eruption—which took place in 1866—like those of most other volcanic manifestations, may be divided into two categories: 1. Volatile matters exhaled in the form of gases and more or less easily condensible vapors; and, 2. Lavas overflowing in imperfect fusion, or thrown out as ashes and scoriæ. The gases varied greatly in composition during the course of the eruption. At the beginning, when they had not been subjected to the action of the air, they were rich in combustible elements, particularly in free hydrogen, arising in some cases from the separation of water into its two elements. At a later stage, the gases varied incessantly in composition, and the combustible elements at last entirely disappeared. The emitted gases consisted chiefly of free hydrogen, marsh-gas, hydrochloric, sulphuric, and carbonic acids, sulphuretted hydrogen, and nitrogen. Water played a prominent part in the different phases of the eruption. In the state of vapor it was present in all the emissions of volatile matters whatever was their temperature, and it might be regarded as the immediate cause of the explosions. No dry smoke-vent was observed. Coming in its liquid state from hot springs, the temperature and flow of the water varied with the state of the sea.

Chloride of iron, expelled as a vapor, was found associated with hydrochloric acid; but the hydrochlorate of ammonia, commonly abundant in eruptions, was almost wanting. This fact lends support to the opinion that the ammoniacal product of volcanoes is of organic origin, and is brought by the atmosphere over vents charged with hydrochloric acid. The distance and the small extent of cultivated lands explain the rarity of ammonia in the air at Santorin.

Over the central eruptive mouths, the points of the volcano where the incandescence was most lively, the spectroscope showed the presence of volatilized salts of soda and potash. After the eruptive manifestations had ceased, the salts which were deposited around the orifices of the vents were collected and analyzed, and appeared to consist largely of the chlorides of sodium and potassium, the sulphates of soda and potash, and the carbonates of soda and magnesia. Sea-water after evaporation leaves a residuum of analogous composition. These results are interesting in their bearing on the theory that the water of the sea is the immediate ordinary agent of the eruptions. All of the elements usually occurring at volcanic vents were found to be present at the points which were the seat of a volatilization of alkaline salts, lending support to the opinion which had been previously drawn from studies made at Etna, that the vents at their highest temperature present at once all the chemical elements of the volatilized bodies in the volcanoes, and that the cooler vents are gradually impoverished as their temperature becomes insufficient for the reduction of the eruptive materials to vapors.

Some of the volatilized substances in the volcanic conduits are susceptible of reacting on each other and producing fixed compounds. Thus are engendered the hydrated oxides of iron, specular iron-ore, free sulphuric acid, alum, and sulphate of lime, which are met around the vents.

Certain crystallized silicates, however, generally originate under different conditions. Although they are formed of elements which we are in the habit of considering fixed, they are found in the volcanic vents, on the surface of the rocks, under such conditions that they could have been produced only through volatilization. Such silicates have been gathered at Santorin in the interior of tubular cavities like fulgurites, which have evidently been traversed by vapors at a very high temperature. The deposited crystals are of anorthite, sphene, and pyroxene under the forms of fassaïte and augite.

Other crystallized silicates are met occasionally in the lavas. They arise from the transformation of the calcareous masses which are taken from the subsoil in the region and carried out in the lavas, and consist chiefly of anorthite, fassaïte, the melanite garnet, and Wollastonite. The quartz and mica-schist, which, like the limestone, appear as inclosed lumps in the lava of Santorin, do not seem to have suffered any action from the matter surrounding them, notwithstanding the high temperature it possessed.

The mineralogical study of the lavas of 1866 offered great difficulties, on account of the small size and strong adherence of the mineral integrants. It was not practicable to extract the crystals by picking them out, and M. Fouqué was obliged to seek new processes. One, founded on the employment of a powerful electro-magnet to draw out the ferruginous minerals, permitted the isolation of the feldspar; and other minerals, harder to deal with, were separated by the use of concentrated hydrofluoric acid.

The crystallization of minerals in the recent lava took place in two stages. In the first stage were developed crystals which frequently attained the length of about a fiftieth of an inch, and of which the other dimensions exceeded a tenth of that size; and, in the other stage, crystals of notably small dimensions were produced. The latter crystals, or microliths, unite the others and follow their contour. Before the microscope was applied to the study of the rocks, only the larger crystals were recognized, and the matter which in volcanic rocks envelops crystals large enough to be perceived through the glass was supposed to be wholly uncrystalline. In this matter, however, the microliths abound in immense quantities. The discovery of them has been one of the most signal triumphs of microscopic micrography.

The minerals observed in the microliths of the general lava of 1866 are feldspar and titaniferous oxide of iron. The predominant feldspar in large crystals is the labrador, but anorthite, and some oligoclase and sanidine are also found in the same condition. The microlithic feldspar is albite with a considerable proportion of oligoclase, and the whole is cemented with a vitreous matter which represents the residue of the crystallization, the part of the rock to which the latter owed its fluidity, at the moment when the minerals which had made a portion of it were already crystallized. This amorphous matter is of a composition similar to that of albite, but a little richer in silica and potassa; and it is curious that a substance of such a composition should have constituted the part of the rock which remained longest melted.

The order of crystallization of the minerals was as follows: 1. Magnetic oxide of iron in large crystals; 2. Apatite; 3. Silicated magnesian irons (augite and hypersthene); 4. Feldspars in large crystals; 5. Microlithic granules of titaniferous oxide of iron; 6. Feldspathic microliths.

The general lava of the eruption of 1866 contains as inclosed masses lavas, the mineral composition of which differs considerably from that of the medium which surrounds them, of types which have a considerable part in the constitution of the ancient lavas of the volcano. The minerals of the recent lava are generally penetrated by foreign matters, microscopic inclusions which are sometimes crystalline, sometimes composed of amorphous matter. The latter inclusions are portions of the surrounding matter which remains inclosed in the crystals at the moment they are formed, and nearly always contain a bubble of gas, in which M. Fouqué found minute quantities of matter analogous in its properties to organic matter. Jets of ashes were cast out in many of the spurts of the eruption. These ashes are lava pulverized by the quick passage of gases and vapors through it while it was still more or less fluid. Its condition as to crystallinity depends on the condition of the lava at the moment it became an ash. The more fluid the lava, the more like pumice is the ash. If the lava has become charged with crystalline substances, especially if they are microliths, the ashes will offer the same characteristics. In the present case the ashes, being derived from lavas which were so crystalline that they were hardly fluid, were rich in crystals and microliths.

Remarkable movements of the soil have been produced by the eruptions within a limited space around the principal cones of the volcano, and have notably modified the surface of the land to that extent. These manifestations have always been special subjects of study with geologists.

Besides the phenomena already described, the complete development of an eruption involves: 1. The opening of the ground; 2. The formation of a cone or crater; 3. The production of a stream of lava. All these manifestations took place during the last eruption at Santorin. Eruptions analogous to those of 1866 have taken place in the Bay of Santorin since the beginning of the historical period, and have given rise to the islands which are known as the Kamenis. The bay itself was created by a catastrophe which was anterior to history, for no writer of antiquity mentions it. Yet remains of habitations have been discovered in the lava, with numerous objects and domestic utensils, which lead to the conclusion that a civilized population, who had already developed artistic tastes, were its witnesses and victims. Judiciously conducted excavations and microscopic examinations of their potteries have furnished much information concerning these ancient people. They were laborers and fishermen; they had flocks of goats and sheep, cultivated grain, made meal, extracted the oil from olives, wove cloths, fished with nets, and lived in houses with walls of squared stone and wooden beams. Most of their tools were of stone, the common ones of lava, others of flint or obsidian. They were acquainted with gold and probably with copper, but those metals were rare with them. Woods were abundant, although there now exists only a single tree, a kind of palm, in all the archipelago. The vine, which is now cultivated almost exclusively, seems to have been unknown at that period.

The islands of Théra, Thérasia, and Aspronisi are the remains of a large island which existed before the formation of the bay. Their soil is composed of three classes of rocks: metamorphic rocks (marbles and mica-schists), volcanic rocks of subaërial formation, and volcanic rocks of submarine formation. Volcanic products of subaërial formation are the only ones in view in the larger part of the group. They appear as compact lavas, scoriæ, pumice, and in dikes. Fragments of the rocks in the dikes have been subjected to examination like that which was given to the lavas of the recent eruption, and the study has been applied to the solution of the problem of the specification of the triclinic feldspars. By it M. Fouqué has been led to conclude that the four varieties so described are distinct.

M. Fouqué accounts for the origin of Santorin by supposing that there was an island composed of marbles and mica-schists, against which submarine eruptions took place; a considerable upheaval then occurred. The eruptions having become subaërial, masses of matter were thrown out from different vents, and produced a large island, the slopes of which became wooded and its valleys fertile, while its summits continued to be rugged with lavas. A violent convulsion, accompanied and followed by formidable explosions and showers of pumice, hollowed out the bay. Finally, eruptions which have taken place since the beginning of the historical period have produced the Kamenis.

The phenomena of this volcano, which is one of those that were cited by Leopold von Buch, the principal advocate of the theory, as examples of the mode of formation which he suggested, have been carefully studied in view of their bearing upon the theory of craters of elevation. They appear, in the light of M. Fouqué's investigations, to contradict this theory at every point, to sustain the old arguments which have been brought against it, and to offer other features which are irreconcilable with it; so that the conclusion is reached that the theory must be definitively abandoned.—*Revue Scientifique.*

BIOGRAPHICAL SKETCH OF FREDERICK WÖHLER.

By Professor CHARLES A. JOY.

FREDERICK WÖHLER, the Nestor of German chemists, was born July 31, 1800, in the little hamlet of Eschersheim, near Frankfort-on-the-Main, in the house of the village pastor who was his uncle by marriage. How it happened that the mother was away from home at such an important period—for this was not her residence—is worthy of record, as it shows that there were heroic elements in the family for the son to inherit. The father held the office of equerry to the Elector of Hesse-Cassel in the early part of this century. This Elector is celebrated in history for the violence of his temper. He was one day visiting the royal stables in company with the equerry, and on this occasion was so particularly insulting and unreasonable that, endurance having ceased to be a virtue, Wöhler seized a horsewhip, and then and there gave his Royal Highness such a castigation as he had often enough richly merited, but doubtless never expected to receive. The equerry then jumped upon the back of the fleetest horse in the stables, and, accompanied by a groom who was to return the steed, soon put a safe distance between himself and the impending wrath of his sovereign. The august Elector, fearing ridicule, thought it wisest to let the matter drop, and never pursued the fugitive. It became necessary, however, for the family to make a hasty retreat from Cassel, and the wife took refuge in the house of her sister, where she remained until the birth of the subject of our sketch. The parents subsequently purchased a small estate at Rödelsheim, where they resided until 1812, when they removed to Frankfort.

Frederick's first instruction in writing, drawing, and later in French, was imparted by his father, who was a university-bred man of unusual intelligence. When he was about seven years old he attended the public school, and received, in addition, private lessons in Latin, French, and music. A fondness for experiments and for making collections early manifested itself, and was judiciously encouraged by his father and an intimate friend who had, in the capacity of private tutor to a nobleman, spent some time at the University of Göttingen, and had, while there, devoted special attention to the study of the natural sciences. This friend owned considerable chemical and physical apparatus, with which he exhibited experiments to the boy, and also allowed the youth to practice his skill, particularly with the battery, which was the great novelty of the day. In addition to these experiments, all sorts of minerals which presented any peculiarity of appearance were collected for future examination.

In 1814 Wöhler entered the high school (gymnasium) at Frankfort, where he prepared for the university. Among his teachers at the gymnasium were several men who afterward became renowned for their learning and special acquirements, namely, F. A. Schlosser, Grotifend, and Carl Ritter. The boy was faithful in his attendance upon the exercises of the school, and satisfactorily passed all of his examinations, but was not distinguished for much knowledge of the ancient languages; indeed, his passionate love of the chemical and physical sciences and his zeal in collecting minerals absorbed so much of his time and tempted him so frequently to neglect both the classics and mathematics that private tutors were occasionally necessary to coach him over difficult passages or knotty problems. He kept up a system of exchange of minerals with his fellow students, and with dealers, especially with Hermann von Meyer and with Herr Menge, in Hanau, to the latter of whom he carried many a bagful of hyalite collected by himself. An important influence was exerted upon the scientific bent of his mind by Dr. Buch, a very intellectual and learned man, who occupied himself largely with chemical, physical, and mineralogical studies, with whom Wöhler enjoyed for years a most instructive intercourse, and to whom he subsequently expressed his indebtedness for the first serious encouragement to pursue scientific studies. Dr. Buch had improvised a laboratory in his kitchen, where, on certain days, experiments were allowed. Among other things, aided by his young pupil, Dr. Buch analyzed some pyrites from Bohemia, in which he found the recently discovered element selenium, and published the result in Gilbert's "Annalen," to the great satisfaction of Wöhler, who then, for the first time, saw his name in print. The two also prepared some cadmium, another new metal, from zinc-ore.

Wöhler afterward carried with him on a pedestrian tour to Cassel and Göttingen a specimen of what he had prepared, in order to show it to its discoverer, Professor Stromeyer, and to have him identify it as genuine. It was during this visit that he made the acquaintance of the celebrated Blumenbach, whose text-book of "Natural History" he had zealously studied. Blumenbach received the young student very cordially, and kindly showed him the curiosities of his natural history collection. He could hardly have anticipated that a few years later the young man would become his colleague at the university, as the successor to the lamented Stromeyer.

By slow degrees Wöhler obtained more correct ideas of chemistry, and abandoned the doctrine of phlogiston, in which, without fairly comprehending it, he had at first believed. Dr. Buch's rich library was always open to him, and he was not, as formerly, confined to Hagen's old "Experimental Chemistry," which had been used as a text-book by his father. Chemical experiments now became a passion with him, they absorbed his mind by day and night; his room at home was transformed into a laboratory full of glasses, retorts, washing-bottles, and minerals—everything in the greatest confusion. No coal-hod in the kitchen was safe in his sight, and it remains a wonder to the present day that he did not set the house on fire or poison some of the family by his operations in the kitchen! The breaking of a flask of chlorine at this period nearly suffocated him, and some severe burns by phosphorus suggested greater caution. He was particularly interested in experimenting with the voltaic battery, and succeeded in constructing one with one hundred small pairs of plates, with which he repeated Sir Humphry Davy's experiment of the isolation of potassium. All his efforts were now concentrated upon an attempt to prepare potassium in a chemical way, according to the method proposed by Curadeau. An old graphite crucible, which Bunsen, the director of the mint, gave to him, served as furnace, and, armed with a bellows loaned by the same person, the experiment was tried in the laundry, with his sister as assistant to blow the bellows. Great was his rejoicing when he perceived the balls of metal in the gun-barrel attached to the retort, and the sister was hardly less gratified at the result of their combined efforts. But the young chemist carried on other studies, to the detriment of his Latin and Greek. He constantly had instruction in drawing, to which his father, who himself drew well, attached much importance. He learned to draw from Nature, and his sketch-book always accompanied him on his excursions in the neighborhood and on the Rhine; he even tried painting in oil, and etching, for which he received much encouragement from the painter Morgenstern.

A rich present of antique Roman coins, which a friend of his father made him, increased his desire to collect similar ones to such a degree that he succeeded in getting together all of the coins of the Roman emperors in their order of succession; Roman urns, lamps, legion-stones, which at that time were still found in the ancient Roman encampments of the neighborhood, were also collected, and aroused in him much interest in Roman history. He likewise commenced to occupy himself with German literature, and to make himself acquainted with the poets of the last century, in which studies a young artist, his drawing master, was his guide. He was too young to appreciate the great political movements of the time, yet he always remembered with interest having seen Napoleon I. during his triumphal entry into Frankfort, and later the passage of the allied troops and Cossacks. His father bestowed particular care upon his son's physical development, and upon his strengthening of a naturally weak constitution by regular exercise, riding, fencing, swimming, and boating.

At Easter, 1820, when he had nearly completed his twentieth year, Wöhler graduated at the gymnasium and entered the university. Partly in accordance with his own inclination, and partly because favorable circumstances promised him success, it was decided that he should study medicine.

He spent his first year at the University of Marburg, where his father had also studied, and where many of his father's friends could befriend and guide him. He attended the lectures on botany, zoölogy, mineralogy, physics, and anatomy, and began during the winter to perform dissections. But chemistry continued to be his favorite study, and, much to the disgust of his landlord, he transformed his parlor into a laboratory, and occupied himself with the study of sulpho-cyanic acid and cyanogen compounds in general. He discovered iodide of cyanogen, for to him at least it was a discovery, as he was not aware at the time that Davy had previously prepared it. In the joy of his heart he communicated the discovery to Wurzer, the Professor of Chemistry at Marburg, to whom it was also new, but, instead of receiving commendation, he was reprimanded for neglecting his medical studies to carry on original investigations. After spending one year at Marburg, Wöhler went to Heidelberg, filled with enthusiasm for Leopold Gmelin, who became his most cherished friend and master. He wished to attend Gmelin's lectures on chemistry, but was told by that professor that it was superfluous, and he accordingly abandoned the idea, and thus secured more time for work in Gmelin's laboratory and for intimate personal intercourse with this amiable and learned man.

Nearly all the time which his medical studies left him he devoted to chemistry, and even toward the close of his course, when practical medicine became very absorbing, he still continued to spend several hours daily in the laboratory. He resumed his researches on sulpho-cyanic acid at Heidelberg, and commenced those on cyanic acid, the results of which, at Gmelin's solicitation, were published in Gilbert's "Annalen." It was of great service to Wöhler at this time that Gmelin and Tiedemann were engaged upon their physiological researches, thus encouraging him to a similar line of study. He enjoyed to a high degree the esteem of Tiedemann, and owes to this excellent man the kind encouragement to pursue physiological researches, which proved so important in Wöhler's future career. Wöhler was one of the competitors for the prize offered by the medical faculty for a thesis on the "Migration of Matter into Urine," and had the good fortune to be successful. Among other things, it was shown by this research that plant-alkalies, in their transformation through the blood, are changed into carbonates. In September, 1823, Wöhler passed the university examination, and received the degree of Doctor of Medicine and Surgery, "*nec non artis obstetriciæ*."

Immediately after leaving the University of Heidelberg it was Wöhler's intention to visit the larger hospitals of Europe, as a further preparation for the practice of his profession, but Gmelin advised him to abandon the uncertain practice of medicine and to devote himself solely to chemistry, for which specialty he had shown such decided inclination and talent. Acting upon this advice, Wöhler wrote to Berzelius for permission to study in the laboratory at Stockholm, and received from the great Swedish chemist the following answer: "Any one who has studied chemistry under the direction of Leopold Gmelin has very little to learn from me; but, nevertheless, I can not forego the pleasure of making your personal acquaintance, and will therefore cheerfully accept you as the companion of my labors. You can come whenever it is agreeable to you." Armed with this permission, Wöhler at once made preparations for the journey. As his means were limited, he decided to take a sailing vessel from Lübeck, but when he reached that port he found that there was only a small craft in the harbor destined for Stockholm, and that it would be six weeks before she would sail. Of this delay he says, in a sketch furnished to the Berlin Chemical Society in 1875: "I could hardly have endured the loss of time had I not cultivated the acquaintance of Menge, the Icelandic traveler and genial mineral-dealer, in whose collections I could satisfy my fondness for minerals. I had already made his acquaintance in Frankfort, where I had exchanged specimens with him, and where he on one occasion introduced me to Goethe, who came to buy a fine specimen of copper azurite from Chessy."

Menge introduced him to Kindt, the principal apothecary in Lübeck, for whom he formed a lasting friendship, and with whom he resided the last three weeks of his stay in town. To occupy his time while waiting for the ship to take in cargo, Wöhler undertook, in company with Kindt, to prepare some potassium according to the method proposed by Brunner. Instead of a wrought-iron retort, they made use of one of the bottles in which mercury is furnished to commerce, while a bent gun-barrel served as the neck of the retort. He obtained such a rich supply of potassium that he was able to take a large quantity to Sweden, which afterward proved of great importance in Berzelius's experiments on the isolation of silicium, boron, and zirconium. It was also in Lübeck that Wöhler met for the first time Mitscherlich, who was returning from a visit to Berzelius. At last the ship set her sails, and on the 23d of October, 1823, started for Travemünde, where he took passage on the 25th. After a very stormy passage the vessel dropped anchor at Dalarö, a small port situated on the rocky coast, whence, to avoid a long sea-voyage, he decided to go by land to Stockholm. The officer of the guard who examined his passport, on hearing that he was going to study with Berzelius, declined to accept the usual fee, saying he "had too much respect for science and his celebrated countryman to take money from one who, in the pursuit of knowledge, had undertaken so long a journey." Wöhler arrived at Stockholm at night, and early the next morning could hardly restrain his impatience to call upon the great master.

Berzelius had an official residence in the Academy of Sciences, and a medical student, whose acquaintance he had casually made, showed the way. We will let Wöhler himself describe his first interview: "With a throbbing heart I stood before Berzelius's door and rang the bell. A well-dressed, dignified gentleman, with florid and healthy complexion, let me in. It was Berzelius himself. He welcomed me very cordially, informed me that he had been expecting me for some time, and wished me to tell him of my journey—all this in the German language, with which he was as familiar as with French and English. When he conducted me into his laboratory I felt as if I were in a daze, doubting whether I found myself in reality in these classic walls and in the fulfillment of all my dreams. He took me the first day to the institute, where he gave his lectures to medical students, but which were attended by officers of the army and several of his friends, and which I regularly visited afterward to accustom my ears to the language. This afforded me opportunity to admire his calm and clear delivery, and his skill in performing experiments. In this institute was also the laboratory for medical students, which was presided over by Mosander." The following day Wöhler at once set to work. He was provided with a platinum crucible, a balance with weights, and a wash-bottle, but had to furnish his own blowpipe, the use of which Berzelius strongly recommended. He was at that time the only pupil, as Mitscherlich, Henry and Gustavus Rose, had preceded him, and Magnus was his successor. The laboratory consisted of two common rooms, with very simple accommodations. There were neither furnaces, nor ventilators, nor water, nor gas. In one of the rooms were two pine tables, at one of which Berzelius had his place, while Wöhler worked at the other. There were the usual cases for reagents, a glass-blowing table, a water-trough, under which stood a pail, and where the cook Anna came every day to wash the soiled vessels. This cook was a famous character, and ruled over the establishment with despotic sway. As she was one day cleaning some vessels, she remarked that they smelt strongly of oxidized muriatic acid. "Look here, Anna," said Berzelius, "thou must not call it oxidized muriatic acid any longer, but chlorine—that is better."

Berzelius was at this time engaged upon his beautiful researches on hydrofluoric acid, silicium, boron, and zirconium. It was most instructive for Wöhler to follow these researches and note the methods pursued by the great Swedish chemist. After a hard day's work in the laboratory, Wöhler generally spent his long evenings in studying the Swedish language, and in translating Berzelius's treatises for Poggendorff's "Annalen." Sometimes Berzelius would retain him at his house, and entertain him with stories of Gay-Lussac, Thenard, Dulong, Wollaston, H. Davy, and other scientific celebrities, with all of whom he corresponded, and whose letters he preserved in separate portfolios. He permitted Wöhler to read his correspondence with these celebrated men, and also to peruse his journal of a visit to Paris and London. When the weather became more moderate and the days grew longer, Wöhler made short excursions to the mines, factories, and mineral deposits of the neighborhood of Stockholm, on some of which occasions he was accompanied by Berzelius. The first analysis which Berzelius gave Wöhler to make was that of a new zeolite. In reality he performed the work himself, in order to show his method and all the manipulations peculiar to himself. "Afterward," says Wöhler, "he gave me a mineral called lievrite to analyze, which, as a test of my perseverance, I had to repeat till the results were uniform. If I had been hasty and the results did not agree, he would say, 'Doctor, that was quickly but badly done.'" Besides mineral analyses Wöhler prepared selenium and lithium, and repeated his experiments on hydrocyanic acid, which Berzelius had highly commended in his "Jahresbericht," and which he thought had contributed largely to establish the accuracy of the new chlorine theory. After the work in the laboratory ceased, Berzelius had promised Alexander Brongniart and his son Adolph, the botanist, to be their companion and guide on a geological journey through Sweden and Norway. Wöhler was invited to join this party, and gladly accepted the invitation. As the Brongniarts were not to arrive in Sweden before the middle of July, Wöhler improved the interval by making an extensive tour to a number of celebrated mines and quarries where he gathered a rich store of rare minerals to send to his German friends. He finally joined Berzelius at Skinskatteberg, the estate of Hisinger. The venerable and hospitable Hisinger, so well known for his contributions to the geology and mineralogy of Sweden, and also for the liberality with which he had supported Berzelius during the commencement of his studies, lived here, a very rich man, on a princely estate, surrounded by magnificent forests, gardens, and mines. The party spent a week here most delightfully, examining and testing minerals with the blowpipe and visiting mines. While they were waiting for the arrival of the Brongniarts, a traveler brought the news that Sir Humphry Davy was in Götheborg, and that he hoped to meet Berzelius before he left this part of the country. In the mean time the Brongniarts and Hans Christian Oersted arrived, but, being impatient, could not await the arrival of Davy, and continued their journey. Berzelius and Wöhler staid behind, and, in a few days, Davy's arrival was announced, and Berzelius at once waited upon him at his hotel. "The meeting of these two men," says Wöhler, "was very cordial"; and he adds, "Davy addressed some encouraging words to me when I was presented to him as a young chemist." Davy returned to England, while the rest of the party continued their journey to Norway. While at Christiania they encountered the Crown-Prince Oscar, then Viceroy of Norway, and, not being able to escape in time, were detected by the Prince, who stopped the procession, and called Berzelius to his carriage and asked him to dinner. Here was a dilemma; but Berzelius contrived to procure the necessary court costume, and to answer the summons to the royal presence.

This journey to Norway was one of the bright periods in Wöhler's history, and he always recalls it with pleasure to his pupils whenever they ask him for the recital. Finally, in September, 1824, Wöhler took leave of Berzelius, and returned to the Continent. He stopped at Göttingen on his way to Frankfort, where he made the acquaintance of Hausmann, who subsequently became his much-valued friend and colleague. During a visit, which he immediately afterward made to Gmelin and Tiedemann, and in accordance with their advice, he decided to apply for the position of docent at the University of Heidelberg. While preparing to habilitate himself at the university, he enjoyed the intimate friendship of Dr. Buch and of the celebrated astronomer Sömmering, who was then much occupied with observations on the sun's spots, and with experiments on the concentration of alcohol through membranes. Wöhler undertook at this time the translation of Berzelius's "Jahresbericht," which Christian Gmelin, of Tübingen, Berzelius's first German pupil, transferred to him, as he himself could no longer continue it. Wöhler was the more willing to undertake this translation, as the sale of the book promised to defray by degrees the expense of his Swedish journey. It was while thus engaged at the University of Heidelberg, in 1824, that Wöhler first made the acquaintance of his life-long friend Justus von Liebig. The meeting of these two men took place at Frankfort. By a singular coincidence they had been working in the same direction on cyanogen compounds, and there was a slight scientific misunderstanding between them; but all this was at once dissipated when they met for personal explanation, and the two young men formed a friendship which continued unbroken to the time of Liebig's death. Finding that their ideas ran in parallel directions, instead of opposing each other, they decided to work together, and for many years they kept up frequent correspondence, met regularly for consultation, and spent their vacations together among the mountains. Liebig's hospitable home in Giessen and Munich became the headquarters for Wöhler, Buff, Kopp, and others, and here were subsequently planned many of the scientific researches which have so greatly enriched our chemical literature. When Liebig and Wöhler first met, the former was not twenty-one years of age, and the latter was only twenty-four; and yet both had become renowned already for their important discoveries. It is no disparagement to Liebig to say that the acquaintance with Wöhler was of inestimable value to him. The young man needed the quiet, thorough, and solid character of Wöhler to check his own too vivid imagination, and prevent him from jumping too hastily to conclusions. Liebig was quick and impulsive, Wöhler was slow and sure, and the two characters worked admirably together, the one supplementing the other. In after-years they were so much together that it would be difficult to say how far any investigation was absolutely original with either of them. They compared notes on all occasions, and it was especially Liebig who hesitated to publish until he had subjected his paper to the cool criticism of his friend. No envy and no jealousy appear to have cast a shadow upon their friendship, and the large accumulation of letters in Wöhler's hands testifies to the tribute of respect and affection which Liebig showed toward one who could have been a most dangerous rival.

Wöhler's career took an unexpected turn during the winter of 1824–'25. The Gewerbeschule was at that time founded in Berlin. It consisted of but one class in the beginning, to which Henry Rose gave instruction in chemistry. Rose, Mitscherlich, and especially Leopold von Buch, recommended Wöhler for the chair of chemistry in the newly founded institution. To the two former he had been introduced by Berzelius, while Leopold von Buch had previously made his acquaintance while he was a student at the University of Marburg. The young student had made such an impression on Von Buch that he became his devoted friend and patron. Wöhler had found a new variety of harmotome (Phillipsite) in a basalt-quarry near Marburg, and, as Von Buch had in the last century published a notice of this mineral, the new variety greatly interested him, and he was also pleased to find a young man so well versed in mineralogy. When the question of the new position in Berlin was pending, Von Buch wrote a long and characteristic letter to Wöhler in which, with sprightly humor, he described the society and the chief personages of Berlin of that day, and endeavored to persuade the young chemist to select the Prussian capital, in preference to Heidelberg, as a place of residence. Wöhler did not long hesitate, and in March, 1825, removed to Berlin, where he was at once installed, under Director Kloeden, as teacher of chemistry and mineralogy. At first he only took the position on trial for a year, on a salary of three hundred dollars and a modest apartment. By degrees the institution grew in importance, and Wöhler's salary was very much increased, and a fine dwelling was assigned to him; and in 1828, by royal decree, he was raised to the rank of professor. It was at about this time that he was married to his first wife who was the daughter of a wealthy banker of Cassel. The young professor now entered upon a prosperous career. His residence at the capital of Prussia, the great resources which were at his command, the constant scientific intercourse with the favorite pupils of Berzelius, Mitscherlich, Henry Rose, Gustavus Rose, and particularly with his intimate friend Magnus, and the opportunity of meeting with other shining lights of the day, could not fail to exert an inspiring and instructive influence.

Wöhler always considered it peculiarly fortunate that he was here able to make the personal acquaintance of Alexander von Humboldt, and to have the privilege of listening to his intellectual conversations, and of attending his celebrated lectures on Cosmos. In the year 1828 Von Humboldt was made President of the German Association of Naturalists, and opened the session with a most finished and brilliant discourse, and, though crowded with work, he still found time during the meeting of the Association to collect around him a choice circle of specialists, and in particular to show much attention to Berzelius, who was at that time on a visit to Berlin. Von Humboldt gave a breakfast in honor of Berzelius, which was remarkable for the number of celebrated men who were present at it. After the breakfast a drive was arranged to Humboldt's country-seat at Tegel. Here the host exhibited the art-treasures of his brother William, and afterward the whole party drove to the quarry of Rüdersdorf, where geology was discussed by the learned company. On this occasion, Wöhler has reported that it was very interesting to watch the contrast between Humboldt's well-known inexhaustible powers of conversation and Berzelius's quiet demeanor. Wöhler, being the youngest and slightest in stature, had a seat in a dog-cart between Humboldt and Berzelius. While on the way to the quarry, in the midst of one of Humboldt's harangues, Berzelius turned to Wöhler and said in Swedish: "O Lord, how this man does talk! I can't stand it much longer!" Wöhler was greatly embarrassed for fear that Humboldt would overhear the remark, but, as he kept on talking, this anxiety vanished.

This was, perhaps, the most prolific period of Wöhler's life, for at this time he published his famous researches on aluminum, glucinum, yttrium, and, in association with Liebig, on cyanogen, cyanic and uric acids. Gay-Lussac had proposed the question in the early part of the century whether, when cyanogen was treated with alkalies, a cyanic acid might not be produced, and it was in answer to this question that Wöhler published his first paper in Gilbert's "Annalen" in the year 1822. It was at the same time that Liebig, then a boy in years, had gone to Paris to show Gay-Lussac what he had done in the same direction; and it was Humboldt who aided the boy chemist in Paris, just as he did Wöhler in Berlin in later years. Subsequently, as we have seen, Wöhler and Liebig made common cause of this investigation, and published their researches together. But the most important research of Wöhler falls in the year 1828.

This was the artificial production of urea. This investigation forms an epoch in the history of chemistry. Previous to this time the so-called organic world and the functions of vital force were believed to constitute a realm by themselves. Berzelius had said distinctly in his great text-book that we should never be able to imitate the products of vital force in our laboratories. We could destroy and could build up material things, but to imitate the vital forces would always be impossible. Wöhler, at the age of twenty-eight, overthrew this theory and created a revolution in the domain of chemistry. He made a breach through what appeared to be an impenetrable wall, and this opening has gone on increasing ever since, until it would appear as if, in a few years, no wall would be left standing. Berzelius's estimate of the value of the research on artificial urea is given in a most genial letter which he wrote to Wöhler in January, 1831, and which has recently been published in Germany. Wöhler had found in a mineral what appeared to him to be the oxide of an unknown metal, and he sent a specimen of the strange substance to Berzelius with an interrogation-mark. The new substance proved to be oxide of vanadium, and the fact that Wöhler narrowly escaped discovering it led Berzelius to write the following letter, which we translate entire:

STOCKHOLM, *January* 22, 1831.

. . . . In reference to the specimen sent by you, designated with an interrogation-mark, I will relate the following story: In the remote regions of the north there dwells the goddess Vanadis, beautiful and lovely. One day there was a knock at her door. The goddess was weary, and thought she would wait to see if the knock would be repeated, but there was no repetition, and whoever it was went away. The goddess, curious to see who it could be to whom it appeared to be a matter of so much indifference whether he was admitted or not, ran to the window to look at the retreating figure. "Ah!" said she to herself, "it is that fellow Wöhler; he deserves his fate for the indifference he showed about coming in." A short time afterward there was another knock at the door, but this time so persistent and energetic that the goddess went herself to open it. It was Sefström who appeared at the threshold, and thus it was that he discovered vanadium. Your specimen is, in fact, oxide of vanadium. But the chemist who has invented a way for the artificial production of an organic body can well afford to forego all claims to the discovery of a new metal, for it would be possible to discover ten unknown elements without the expenditure of so much genius as appertains to the masterly work which you, in association with Liebig, have accomplished and have just communicated to the scientific world.—JOHAN JAKOB BERZELIUS.

Notwithstanding the great advantages which his position offered in Berlin, and the favorable prospects open to him in the future, Wöhler was constrained, for domestic reasons, to resign his professorship in 1832, and to remove to Cassel, where his wife's family resided. For several years he held no official position, and occupied himself with the translation of the third edition of Berzelius's text-book of chemistry, and with the yearly reports. He spent some time with Liebig, at Giessen, where the two friends completed their important research on the oil of bitter almonds. The large supply of arsenical nickel which had accumulated as an incidental product at the prussian-blue factory in Cassel led Wöhler to invent a method by which the nickel could be economically separated, to be subsequently used in the manufacture of German silver. The process succeeded so well that extensive nickel-works were established, yielding many thousand pounds for exportation to Birmingham. He, at that time, proposed nickel as a suitable metal for coinage, but no attention was paid to the suggestion. While Wöhler was residing at Cassel, a Gewerbeschule, similar to the one in Berlin, was founded, and he was appointed to a position corresponding to the one he had held in Berlin, and was one of the three officials upon whom devolved the organization of the new institution. Afterward Professors Buff and Phillips were added to the corps of teachers.

Wöhler's duties as professor at the Gewerbeschule naturally directed his attention to technical chemistry, and in the autumn of 1833, in company with his intimate friend Magnus, he made a journey to France and England, to visit laboratories and chemical works, and on this tour had the opportunity to become personally acquainted with the most eminent living scientists of that period. In March, 1836, Professor Stromeyer having died the previous year, Wöhler was called to Göttingen as Professor of Chemistry and Pharmacy, Director of the Laboratories, and Inspector-General of all the Apothecaries of the Kingdom of Hanover. His place in Cassel was supplied by Professor Robert Bunsen, who previous to that time had been a docent at Göttingen, and at the present time is the renowned teacher at the University of Heidelberg. Wöhler could not at first refuse the post of Director of the State Apothecaries, and for twelve years traveled over the kingdom at great inconvenience and loss of time; he finally resigned this branch of the service, and gained more time for research. He has been seven times elected Dean of the Medical Faculty, until he declined a further nomination.

In 1860 Wöhler was made permanent Secretary of the Royal Hanoverian Academy of Sciences, to succeed Hausmann, and this position he continues to hold at the present time, attending to all the duties of correspondence with the punctuality of a young man, recalling his intimate friend Dumas, who at the same age holds a similar post in the French Institute.

In 1873 the fiftieth anniversary of Wöhler's doctorate was celebrated with great pomp by the students of the university, and on the 31st of July, 1875, being the fiftieth year of his active career as a teacher, and the seventy-fifth of his age, addresses and congratulations were poured in upon him from all parts of the world. During the current year, on the occasion of the eightieth anniversary of Wöhler's birth, the demonstrations of honor and rejoicing will be general at all of the seats of learning in Europe and America, and a presentation of a gold medal will be made to him to commemorate the interesting event. In the course of a long and distinguished career, the universities, learned societies, and sovereigns of Europe have vied with each other in conferring honors upon Wöhler. He received the Order of Merit from Prussia, the highest title of dignity from Hanover, and was elected one of the eight foreign associates of the French Institute, and the Emperor Napoleon made him an officer of the Legion of Honor; and so many decorations and diplomas have been presented to him that the mere catalogue would fill a page. The principal published works of Wöhler have been his translations of Berzelius's "Yearly Reports," and Berzelius's "Text-book of Chemistry"; also "Grundriss der Unorganischen Chemie und der Organischen Chemie"; "Mineral Analyse mit Beispielen," etc. These books have passed through numerous editions, and latterly the "Organic Chemistry" has been edited by Professor Fittig, formerly Wöhler's assistant at Göttingen. During the last fifty years Wöhler has published in Gilbert's, Poggendorff's, and Liebig's "Annalen" more than two hundred and fifty different papers on chemical subjects, or an average of five every year. Although these contributions have been of great importance to the progress of the science, the crowning glory of Wöhler must be sought in the influence he has exerted as a teacher of chemistry. During the last forty-four years his laboratory at Göttingen has been the workshop in which great numbers of students have been taught how to conduct original researches, and many of these pupils have become professors all over the world. All of those who took their degrees must have presented an original thesis; and in nearly every instance, although the student performed the physical labors of the research, the suggestion, the topic, and the method came from Wöhler. It is difficult to measure the importance of such a life, or to express in fitting terms the gratitude we owe the man. All who have had the privilege of nearer relations to him have learned to love him as a man, revere him as a teacher, and respect him for the profundity of his knowledge.

Professor Wöhler has been twice married. His first wife died many years ago, leaving a son and daughter. His only son now resides near Göttingen, and is a wealthy landed proprietor; the daughter by the first marriage is the wife of the Burgomeister of Göttingen, and has children and grandchildren, so that Wöhler lives to see several great-grandchildren gather at his family board. By his marriage to the wife who still survives there have been three daughters, all living, two of whom are married, one residing in Hamburg and the other in London. The venerable man is surrounded by family and friends, with an ample fortune to provide for every want. He has ceased to deliver lectures or to impart instruction in the laboratory, but maintains the liveliest interest in all questions of the day, and in his private correspondence displays the vigor and playfulness of his youth.

CORRESPONDENCE.

OBSERVATION OF THE ENGLISH SPARROW.

Messrs. Editors.

As the habits and value of the English sparrow are now being investigated in various parts of the country, I submit the results of my own observations made during the last three or four years, or since the bird became abundant in this locality. The charge frequently made, that the English sparrow drives our native birds from their accustomed haunts, does not apply to this vicinity. The sparrows are very numerous, are noisy and sometimes aggressive in their habits, but appear to quarrel much more among themselves than with other species of birds. I have not noticed any superior combative power which would enable them to do that which they are charged with doing. They are with us during the year—about our grounds and dwellings in great numbers. They are companions of the song-sparrow, snow-bird, woodpecker, chickadee, creeper, nuthatch, etc. There is no conflict or dispute among them. During the inclement weather of winter I feed the birds frequently, sometimes daily, and have watched their movements with great interest. I have not seen a dispute in their efforts to obtain the coveted food. The woodpeckers and chickadees gathered the bits of meat, the fringilla the seeds, which I scattered.

Nor have I noticed any considerable controversy at the nesting-season. Bluebirds are the first to arrive, and sometimes find their former nesting-places occupied by sparrows, but no disturbance occurs, the bluebirds finding other places for their nests. I have several times noticed, however, that the bluebirds are masters of the situation when a struggle takes place for an empty box. At this writing, bluebirds, sparrows, orioles, and many other species have their nests on my grounds, and equally so on the grounds of others in our neighborhood. I have no doubt there are fifty birds'-nests within a short distance of my dwelling. Robins, blackbirds, cat-birds, orioles, warblers, finches, and fly-catchers of many kinds are all about us, very much more numerous than they were in our boyhood.

All birds of species which love the shade of the woodlands are of course undisturbed by sparrows, which seek open spaces near dwellings, not the forests. Nor will it be claimed that larger birds, such as the robin, suffer from the presence of the sparrows. With us the barn-swallow is among the most peaceful and unobtrusive of birds, and yet it does not seem to be in any great fear of the sparrows, as the following incident will show: A pair of swallows commenced building a nest under a shed on my premises, but a sparrow was soon seen sitting on the side of the half-finished structure. Directly the swallows commenced building another nest within a few feet of the first, and no further disturbance took place. The nest was finished and occupied by the swallows. Sparrows have not driven our native birds away, neither have they given cause for any serious complaint on account of destroying our grain, as they seem to have done in some other places. I think, in this particular, it would be well for people to observe carefully for themselves. In winter, indeed, at all seasons, sparrows delight to feed on half-digested grains thrown from stables, or scattered elsewhere, but in spring and summer I have seen them carrying animal food to their broods. This they do persistently and in large quantities, the supply consisting largely of insects, larvæ, worms, etc. I have seen them catch insects on the wing as do the fly-catchers.

I have not observed that they eat berries, grapes, or other small fruits, but have seen them picking the soft grains of sweet-corn. If their food were scanty or unsuitable, it is probable that they would feed more freely on the valuable grains. The birds which do most damage to farmers in this vicinity are blackbirds, robins, cat-birds, and a few other species, which feed on cherries, blackberries, grapes, and similar fruits. When the fruits are ripe, the trees and bushes swarm with these birds, but we hear of no prejudice against them on that account, while the sparrows are freely condemned for like offenses.

Respectfully, John D. Hicks.

Old Westbury, Long Island, *5th Mo. 18th*, 1880.

AN EXPLANATION.

Messrs. Editors.

The author of the article in "The Popular Science Monthly" of the present month, with the caption "The Classics that educate us," it is probable has not seen President Eliot's interpretation of the passage quoted from the address made at Smith College in 1879. The friends of the higher education looked upon it as an extraordinary statement, and in one of our journals the following criticism appeared: "Will President Eliot offer the public some fuller explanation of his meaning? What training to the powers of observation is given by the study of the mother-tongue? What training to the art-faculties? What to the knowledge of abstract truths? What to the faculties which deal with abstract truths? What to the power of reasoning? Does President Eliot mean that an acquaintance with the mother-tongue trains every faculty which is trained by mathematics, science, metaphysics, and æsthetics—or does he mean that the training of these faculties is not essential to a good education—that education may be partial and yet adequate?"

The statement, President Eliot afterward remarked, "can easily be misunderstood," and was misunderstood, and is still used to prove something that he did not design it should be used to prove. There can be no dispute as to the correctness of the remark that "an accurate and refined use of the mother-tongue is an essential part of the education of a lady or gentleman." No one would consider an education complete without this part of it. A violation of the rules of grammar in speaking or writing the mother-tongue would at once show an imperfect education.

The Rev. Lyman Abbott published Mr. Eliot's explanation. In an article in the "Christian Union" Mr. Abbott remarked: "Our readers may remember an editorial paragraph calling attention to a reported utterance of President Eliot, of Harvard College, on the subject of education. We, at the same time, addressed him a private note, to which we have received the following reply":

"Harvard College, Cambridge, Mass., *July* 26, 1879.

"My dear Sir: Your obliging note of July 3d arrived just after I had left Cambridge for a yacht-cruise on the Maine coast. Hence the long delay of this reply.

"I do not feel inclined, in these blessed vacation-days, to write even the shortest article—not even to justify a statement of mine which, it seems, can easily be misunderstood. I did not say that a study of the mother-tongue supplied a complete mental training; but only that no one was a gentleman or a lady who had not a refined and accurate use of the mother-tongue. That attainment I find essential to my conception of a gentleman or a lady. A gentleman or a lady will have other mental acquisitions; but these will not be essential, as that is. To illustrate: salt is an indispensable article of diet; one may, further, eat bread, or beef, or oatmeal, but salt one must have, whatever the other articles consumed may be. Moreover, neither bread, nor beef, nor oatmeal, is indispensable in the same sense.

"But, as you suggest, the remark quoted and questioned in your paper was incidental; and I am quite willing that it should go for what it was momentarily worth.

"Very truly yours,

"Charles W. Eliot.

"Rev. Lyman Abbott."

We can accept President Eliot's explanation that, as salt is necessary in all our food, so the mother-tongue should appear in its refined and accurate use in all our studies—rather than suppose an incidental remark should be used against the study of the classics. It would be singular, indeed, if the president of a great university should be placed in opposition to the study of subjects which are assigned so large a place in its curriculum as the ancient languages; rather would it be supposed that he would say with Dr. Seelye, of Smith College: "The relation, however, of the classics and mathematics to intellectual growth, if correctly apprehended, rests on unalterable facts in the history of man and the constitution of nature. They are to be studied, not because the college demands them, but because they are an essential condition to the broadest mental culture. Unless they are early taught, the chances are they will never be acquired. Those who wish to pursue a higher education will find themselves embarrassed every step forward without them."

It is evident that the remark of President Eliot was thrown off parenthetically in the address before the young ladies of Smith College, and was never intended to be used as it has been by writers and speakers on the subject of classical studies since the day it was uttered.

We think it is due to classical study and its friends that this explanation should be made in your widely-read "Monthly."

Yours, truly,

Traill Green.

Easton, Pennsylvania, *June* 9, 1880.

A SHOWER OF DUST.

Messrs. Editors.

From two to five o'clock on the morning of March 28, 1880, we had a storm of wind and rain in this part of Indiana. After daylight a remarkable deposit of brown or slate-colored dust was found to have fallen on porticoes, flat roofs, etc. It was also observed, in places, on the earth's surface. The phenomenon was noticed by our citizens generally, and it was spoken of in some of our papers. Professors Wylie and Newkirk, as well as myself, collected quantities of the dust. Some freshly painted buildings retained the marks of the shower for several weeks. The deposit was noticed at places more than fifty miles distant. Mr. J. W. Hollingsworth, of Paoli, Orange County, Indiana, informed me that the fall there was very abundant. I intended at the time to write some account of the remarkable shower, but being then busy I neglected it. My attention was recalled to the matter by an account in "Nature" (April 15th), of a similar shower about the same date, on the opposite hemisphere. Dr. Thomas C. Van Nuys, Professor of Chemistry in the State University, has kindly furnished me the following partial analysis:

Silica, SiO_2, 64·95 per cent.; ferric oxide, Fe_2O_3, 5·39 per cent.; alumina, Al_2O_3, 10·20 per cent.; calcium oxide, CaO, 1·53 per cent.

Yours very truly,

DANIEL KIRKWOOD.

BLOOMINGTON, INDIANA, *June* 24, 1880.

EDITOR'S TABLE.

WILKIE COLLINS ON INTERNATIONAL COPYRIGHT.

WE can not congratulate the English on the treatment of the international copyright question by some of their eminent authors. It was but the other day that we had to point out the lack of good sense exhibited by Matthew Arnold in his very complacent discussion of the subject; and now comes a blast from Wilkie Collins which, although it does not amount to much, is still a perverse and unhelpful utterance. The reputations these men have are certainly not justified by their outgivings in relation to this important measure.

Mr. Collins writes for the "International Review," and is very indignant at the American "thieves" and "pirates" by whom he is "robbed." He seems to think that the main thing now is to brand these rascals indelibly; and so, to insure the full effect of his reproaches, he stipulates with the editors that not a denunciatory word shall be omitted from his paper; and they declare in a note that the said words are every one there, while "they must disclaim all responsibility for the language adopted by him in his argument."

Considerably more is made of this point than it is worth. There is obviously nothing new about it, as excoriating adjectives have been abundantly applied to us before by suffering authors. Nor is there anything objectionable in it; on the contrary, we are glad to see Mr. Collins "call a spade a spade," and mete out to those who steal his books the reprobation they deserve. Strong words are needed to characterize gross wrongs, and we agree that this is a case that calls for them. Mr. Collins is right in venting his righteous indignation in the most telling terms he can command: we only regret that he has been unable to give some freshness and new pungency to his invective.

But, when Mr. Collins gets through with his feeble vituperation, and comes to the practical question of what is to be done, he is then far less satisfactory. As a scold he is commonplace enough, but as a guide to lead us out of difficulty he is without qualification. To his diatribe we say "amen"; to his reasoning we say, "it won't do." He here betrays lack of judgment, and shows himself to be impracticable. We agree with him that there is a palpable and vicious wrong to be set right; but the question is, how to accomplish it. The wrong requires to be defined and limited, that we may know precisely who suffers by it, and what must be the nature and extent of the remedy. The wrong here is, that the American Government does not protect the rights of foreign authors to property in their books; and, as that property is unprotected, it is appropriated by anybody who chooses to take it. Mr. Collins has an undoubted right to be thus protected, and, if he were a discreet man, he would confine his claim to its impregnable ground, and force his case in the direction where no resistance can be offered. But he stretches his claim until he destroys it, as may be easily pointed out.

The ideas and language, the soul and essence of a book—that which properly *creates* it—are contributed by the mind of the author. It is work, the product of toil and skill and time and capital, just as much as any other construction of industry. All civilized countries recognize and guard the right to this kind of property. We do it in this country in the case of our native authors, thus abundantly vindicating the theory and the practice. But we have the illiberality, the narrowness, and the meanness, to refuse this act of justice to foreign authors simply as foreigners. And for this course there can not be conjured up even a decent pretext; we simply want the works of these foreign authors, and outlaw them for the benefit of whomsoever can make money out of their productions. It is the duty of Mr. Collins and all others who are victims of this policy to protest against it as an outrage; and he should demand that his rights be admitted and his property defended by the authority of American law. Here his position is invincible.

Nevertheless, the case is not without its difficulties as viewed in the light of experience. There is no nation that recognizes an author's right in his book as absolute, indefeasible, and perpetual, like the rights to other kinds of property. Book-rights, like patent-rights, are limited, and expire in all countries after the lapse of specified though variable periods. Mr. Collins can not own his book for ever, even in England. It may be that this is unjust; but the demands of ideal equity are nowhere met. As a matter of fact, men have to be content with proximate justice; and the foreign author pushes his claim as far as is wise or expedient or practical, when he demands that the United States shall place him upon an equal footing with American authors as regards protection. Should he require that our Government guarantee his literary rights as interminable, he would so encumber his valid claim that it would be futile to urge it. We simply mean by this, that Mr. Collins has got to take circumstances into account if he proposes to attain a practicable end.

The book-manufacturer is his partner in business, whose office is to take the author's literary creation and give it a material embodiment for public use. The business partner makes copies of the work, publishes it, and manages the sales. He generally furnishes the capital required to produce the desired editions. He pays for the labor of typesetting, for paper, printing, and binding, and when the books are sold he gives the author a stipulated part of the returns. But there is this difference between the parts of a book contributed by the author and by the publisher, that while the author's portion is protected by public law in a qualified way or not protected at all, on the other hand the part contributed by the publisher is protected always and everywhere, and as absolutely as any form of property is ever protected. The American Government will not protect Mr. Collins's right of property in his book, but in every court in the land it will protect the rights of the man who pirates it. The publisher may steal the author's part, but no man may steal the publisher's part without incurring all the penalties of theft. Publishers, therefore, as such, are in need of no protection; they are everywhere abundantly cared for.

Yet it is a great thing for the publisher to get the advantage of that monopoly in the commerce of a book which the author's copyright confers. When he secures this advantage, he can put whatever price he pleases upon the stock which he has worked up into a book. The materials and labor used have their fixed price in the market; but, when the book is produced, the publisher arbitrarily determines what it shall sell for. He is at liberty to fix the scale of his own profits, and as a business man he will always do it with sole reference to his own interest. Various considerations may influence his decision; but the most important fact is, that the copyrighted book will encounter no competition in the market. For these reasons it is of the greatest moment to publishers to make such arrangement with authors as will secure them the large possible benefits of copyright. If the author's interest in a book is represented by ten per cent., than the publisher's interest is represented by ninety per cent.; that is, the publisher is nine times more concerned to get this advantage than the author. Hence the strong desire of foreign publishers to get into the American market under cover of their authors' rights.

Now, Mr. Collins comes over here as the virtual agent and attorney of his English publishers. He first makes an outcry about the violation of his rights as an author in this country, and then he includes as one of these rights the liberty of carrying his publisher with him wherever he pleases. He will only be satisfied with an international copyright law in which this is conceded. But he here asks for a privilege, a convenience, a very profitable condition to his friends, and not for a guarantee of justice to himself. Mr. Collins has rights which ought to be regarded and defended in this country by international arrangements; his English publisher has no such rights, nor can he claim on any principle of justice that our Government should so shape its conventions that he can supply our market, if he pleases, with only English editions of his books. If there were no other way for the Americans to obtain his works, it might be different. Mr. Collins might well demand that there be no impediment to the supply of his publications that would hinder his realizing the full benefit of American sales. But, so long as there are plenty of publishers in this country eager to make contracts with him, it is no wrong—not even a hardship—for him to get what he rightfully asks, on the condition that his books shall be published here.

Mr. Collins unwittingly concedes the case when he undertakes to define his claim. He says: "The object of international copyright is to give me by law (on conditions with which it is reasonably possible for me to comply) the same right of control over my property and my book in a foreign country which the law gives me in my own country. In Europe this is exactly what we have done. When I publish my book in London, I enter it at Stationers' Hall and register it as my property — and my book is mine in Great Britain. When I publish my book in Paris, I register it by the performance of similar formalities—and again my book is mine in France. In both cases my publisher (English or French) is chosen at my own free will." But the same right of control over his property in his book in a foreign country that the law gives him in his own country is exactly what it is now proposed that he should have. His native protection stops with the British Islands and hardly extends to the provinces; his French protection is bounded by the limits of France; and his protection here would be coextensive with our nationality. What more, then, can he ask than an international copyright treaty that shall enable him to register his book in Washington, by which it becomes his American property, with the liberty of playing his free-will from the Atlantic to the Pacific in the choice of a publisher?

Nearly fifty English authors of the highest character have recognized that their rights of property in their books in this country should not be complicated with the interests of their home publishers. They thus simplify the matter completely, and present to the American people the naked issue, Will you pay for what you appropriate? Will you protect our property rights as you protect those of your own authors? Will you render us the justice to which we are entitled by the moral judgment of the civilized world? Mr. Collins wants far more; but, if he has the slightest idea of getting it, we advise him to possess his soul in great patience and abstain from futile flurries, for he will assuredly have to wait a long time before he gets what he wants.

POLITICS AGAINST POLITICAL SCIENCE.

It is needless to call attention to Mr. George's vigorous and impressive article which opens this number of the "Monthly," on "The Kearney Agitation in California," as illustrative of the working of American political and social institutions. The name of the writer and the interest of the topic will cause his contribution to be carefully read. Mr. George closes by invoking the scientific spirit and the scientific method in the study of these phenomena, which he thinks demands the serious attention of the most thoughtful men.

This appeal is legitimate, and is prompted by the inevitable logic of the situation. There must be a far better general understanding of the working of social forces before anything can be hoped from remedial measures; but we are here confronted at the outset with difficulties of a very formidable character. One of the chief of these is that the spirit of our politics is radically anti-scientific. It is essentially hostile to science because it cultivates systematic misrepresentation, while the first requirement of science is allegiance to truth. Science begins with morality. It implies rectitude of thought, exemption from prejudice and passion, and the utmost attainable accuracy in its representations. It is a school—the only school we have—for discipline in truthfulness. Partisan politics, on the contrary—and partisanship is the essence of politics—is a school of deception and falsehood, and all its influences are at war with the fundamental virtue of truthfulness. If it be thought we are going too far in saying that our political institutions educate the people to immorality, we appeal to the highest authority on moral subjects which our country has produced.

More than forty years ago Dr. William Ellery Channing gave a lecture in Boston on the subject of self-culture. In speaking of the means of self-improvement open to the people of this nation he refers to politics, or to the influence of our popular institutions in arousing the mental activity of citizens which thereby becomes a means of general self-education. But, having turned the customary patriotic compliment to this beneficent action of our form of government, Dr. Channing pauses, as if conscious that he had gone too far, and then proceeds in a very different strain to acknowledge that, as a matter of fact, no such benign result is gained. He declares, on the contrary, that the influence of politics is to produce a wide-spread demoralization by a subversion of all the cardinal virtues of character. He says:

> It may be said that I am describing what free institutions ought to do for the character of the individual, not their natural effects; and the objection, I must own, is too true. Our institutions do not cultivate us, as they might and should; and the chief cause of the failure is plain. It is the strength of party spirit; and so blighting is its influence, so fatal to self-culture, that I feel myself bound to warn every man against it who has any desire of improvement. I do not tell you it will destroy your country. It wages a worse war against yourselves. Truth, justice, candor, fair-dealing, sound judgment, self-control, and kind affections, are its natural and perpetual prey.
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> I do not say that you must take no side in politics. The parties which prevail around you differ in character, principles, and spirit, though far less than the exaggeration of pas-

sion affirms; and, as far as conscience allows, a man should support that which he thinks best. In one respect, however, all parties agree. They all foster that pestilent spirit which I now condemn. In all of them party spirit rages. Associate men together for a common cause, be it good or bad, and array against them a body resolutely pledged to an opposite interest, and a new passion, quite distinct from the original sentiment which brought them together, a fierce, fiery zeal, consisting chiefly of aversion to those who differ from them, is roused within them into fearful activity. Human nature seems incapable of a stronger, more unrelenting passion. It is hard enough for an individual, when contending all alone for an interest or an opinion, to keep down his pride, willfulness, love of victory, anger, and other personal feelings. But let him join a multitude in the same warfare, and, without singular self-control, he receives into his single breast the vehemence, obstinacy, and vindictiveness of all. The triumph of his party becomes immeasurably dearer to him than the principle, true or false, which was the original ground of division. The conflict becomes a struggle, not for principle, but for power, for victory; and the desperateness, the wickedness, of such struggles, is the great burden of history. In truth, it matters little what men divide about, whether it be a foot of land or precedence in a procession. Let them but begin to fight for it, and self-will, ill-will, the rage for victory, the dread of mortification and defeat, make the trifle as weighty as a matter of life and death. The Greek or Eastern Empire was shaken to its foundation by parties which differed only about the merits of charioteers at the amphitheatre. Party spirit is singularly hostile to moral independence. A man, in proportion as he drinks into it, sees, hears, judges by the senses and understandings of his party. He surrenders the freedom of a man, the right of using and speaking his own mind, and echoes the applauses or maledictions with which the leaders or passionate partisans see fit that the country should ring. On all points parties are to be distrusted; but on no one so much as on the character of opponents. These, if you may trust what you hear, are always men without principle and truth, devoured by selfishness, and thirsting for their own elevation, though on their country's ruin. When I was young, I was accustomed to hear pronounced with abhorrence—almost with execration—the names of men who are now hailed by their former foes as the champions of grand principles, and as worthy of the highest public trusts.

This is a dark indictment, but Dr. Channing was a man who weighed his words. He represents partisan politics as a blighting influence, fatal to self-improvement, hostile to moral independence, and degrading to character. He says that "truth, justice, candor, fair-dealing, sound judgment, self-control, and kind affections, are its natural and perpetual prey." A system the spirit of which makes "truth" its "natural and perpetual prey," it is needless to say, is not favorable to science. Science can not grow, it can not exist, in such an atmosphere.

If it be said that Dr. Channing wrote forty years ago, the reply is that forty years have not mended matters. There is, on the contrary, every evidence that party ends are now pursued in this country with more recklessness of falsehood and more shameless unscrupulousness than ever before. That "all is fair in politics"—a maxim that would be scouted in the cock-pit and on the race-course—is not a recent rule; but the bad arts of an inveterate partisanship have been gradually perfected. With our political progress principles are progressively eliminated from politics, and first-class men are driven from the field. More and more it is becoming the function of the people merely to ratify at the polls the proceedings of wire-pullers, plotters, intriguing demagogues, caucus-bullies, and convention-desperadoes. It is notorious that our politics has passed into the hands of practiced professionals, who outmanœuvre straightforward men, and drive them to the wall. Everything is done by management and under false pretenses. Party excitement is stimulated by stirring up the meanest passions and by plying all the arts of detraction and falsehood. When the campaign opens, the sluices of slander soon run full. Here comes the last "Evening Post," representing the state of things in 1880. In a leader it says: "As generally conducted, our Presidential campaigns are so volcanic outbursts of passion and prejudice, and are accompanied by such torrents of vulgar calumny, falsehood, and abuse, that they are anything but creditable to our self-respect and tastes. They not only let loose every viler form of uncharitableness and evil-speaking, but they are permitted to absorb the energies of society to such an extent that even commercial activity is arrested, and the best moral and social developments are paralyzed for the time. In these quadrennial saturnalia the participants, for the most part, take leave of their senses, and comport themselves like bedlamites or Mænads." In the national campaign preceding the last, one of the candidates, as we all remember, was constrained to say, "I hardly know whether I am running for the Presidency or the penitentiary." In the last campaign a Presidential candidate received the suffrages of a majority of the people of the United States, but he failed to get the office, and has ever since been hunted with libels and blackened with calumny, until multitudes regard him as a consummate knave, fit only for the State-prison.

In these vile practices of falsehood and detraction the whole country is implicated, for we are a nation of politicians. Politics is not only the dominant subject of thought, but its method is the dominant method of thinking. We have hundreds of colleges and thousands of common schools, multitudinous newspapers and countless pulpits, and all, as we say, for the promotion of public intelligence and the elevation of public morality; but, when election comes, professors, teachers, editors, and clergymen, all join in "saving their country" by the means which Dr. Channing has so fittingly characterized. Whoever is in the pulpit, the pews are filled with politicians; whoever is editor, the subscribers are politicians; all the instructors in our public schools are political stipendiaries, and politicians dictate the studies. Indeed, the reason given for the very existence of these schools is political. As for the colleges, they are more than anything else workshops for the manufacture of politicians; as was sufficiently attested by President Hayes, the other day, when he told them at Yale that the great office-holders are mere figure-heads shaped by the institutions where office-holders are made.

So rooted and so fortified is this political system which perpetually preys upon truth and justice, corrupts the morals of the nation, and flames out in Kearneyism and kindred scandals of a reckless partisanship which disgrace every State in the Union. But, powerfully intrenched as it is, we believe that this system is destined to be ultimately improved if not renovated. But it will be slow work, and the reform will not proceed from within. Politicians engendered by the system will not transform it. The amending and elevating influences must come from without. Men must be thoroughly freed from the system before they can deal with it efficiently. The first thing needed by the American citizen is to gain an independent position for the critical study of the institutions of his country; and this can only be done by vigorous individual revolt against party domination. The powerful spell of partisan influence must be broken before men can be qualified to pursue the study of politics by the scientific method, for under the bias of party feeling nothing is seen aright. Personal independence of action in political matters, freedom from the trammels of partisanship, is the true preparation for the intelligent investigation of political questions. Multitudes of our best people are already thoroughly disgusted with politics. Thousands will not go to the polls except under pressure of violent campaign excitement. Politicians denounce this as unpatriotic; but there can be no duty to one's country so imperative as rebellion against party machinations and behests. In this growth of Protestantism against the immoral tyranny of the old political church is our hope. Mr. George rightly appeals to the spirit and method of science, applied to political and social affairs, as the great agency of national redemption, and time will show that the appeal is well taken. The great love of intellectual advancement is bound in time to give us a science of politics grounded in principles of truth, instead of the quackish arts of partisanship, just as certainly as it has given us a science of navigation, agriculture, and chemical manufactures.

LITERARY NOTICES.

SPENCER'S "EDUCATION." CHEAP EDITION.

Education: Intellectual, Moral, and Physical. By Herbert Spencer. New York: D. Appleton & Co. Pp. 283. Price, 50 cents, paper covers.

This little work has now been twenty years before the public, and during that time has gradually made its way to all parts of the civilized world. It has been rendered into the principal languages of Europe, and is well known by complete or partial reproduction in India, China, and Japan. The eminent directors of public education in different countries have taken the initiative in procuring its translation.* The principles it develops have been avowedly followed in numerous instances in shaping the policy of public instruction, and in organizing educational institutions; and it has exerted a strong influence upon the mental and moral culture of families, and upon the intellectual life of individuals. Desirous of still further extending an influence so well approved, Mr. Spencer a year or two ago issued a cheap edition of the book in England, and the American publishers have now wisely imitated his example.

We do not propose here to notice the book in the usual manner, as most of our readers are no doubt quite familiar with its contents. But this is a suitable occasion to recall the circumstances of its origin; and the more so as thereby some explanation will be afforded of its remarkable influence and success.

The four parts which compose the volume were originally contributed by Mr. Spencer to several English periodicals from 1854 to 1859. The period in which they were written, 1850 to 1860—from his thirtieth to his fortieth year—was the most fruitful in his intellectual career, and may be characterized as preëminently the creative and constructive decade of his life. It was the time of the rapid development and organization of his great ideas. It was then that he arrived at the conception of evolution as a universal law and the basis of a new philosophy; and that he drew up a detailed plan of the reorganization of knowledge from the new point of view. The period referred to was one of transition, or rather of *maturing*, for from early years the subject of progress and development in nature and society had taken a strong hold of Mr. Spencer's mind. All his publications during these ten years are colored and pervaded by the dominant conception of evolution. His work took a wide range, chiefly in the form of elaborate articles printed in leading periodicals. Between 1850 and 1860 he published no less than twenty-five of these essays on a great variety of subjects elucidating the principles of evolution, and illustrating their biological, social, intellectual, moral, and political applications.

Among the subjects then dealt with, Mr. Spencer's thoughts were especially and powerfully attracted to the working of evolutionary law in the sphere of mind. This was a new point of view in mental science. While metaphysicians were confining their studies mainly to mind as an abstraction

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* A noteworthy illustration of this has come to hand since the present article was put in type. The first part of Spencer's "Education"—"*What Knowledge is of Most Worth?*"—has just been translated into modern Greek by the late Minister of Education in Greece. It is significant that, while the New World colleges are neglecting and resisting modern knowledge, that the traditional ascendancy of ancient classics may be maintained, the Greek authorities, on the old, sacred, classical ground, are modernizing their education upon the principle that, in the hierarchy of knowledges, science is supreme.

and in its highest form, Mr. Spencer was drawn to its study in the aspect of growth, and as an endowment of growing organisms. Mind, as conditioned by a nervous substratum and unfolding with it—the genesis of the psychical faculties in all grades of organic manifestation—the law of mental progression from the lowest to the highest animate creatures—these were the problems that absorbed his attention. They were considered in various detached papers, but the subject was also dealt with elaborately and systematically in his treatise on the "Principles of Psychology," published in 1855. Mental phenomena were here first methodically elucidated from the evolution point of view. The development of intelligence was traced upward through the organic series from its lowest rudimental forms through successively higher complications, with the view of determining how the highest forms are produced and the highest intelligence constituted. Ascending from reflex action in the lowest types up through instinct, memory, reason, feelings, and the will, Mr. Spencer then reversed the course of inquiry, and showed by subjective analysis how the highest intelligence may be resolved, step by step, from its most complex into its simplest elements. The work was throughout so original and so closely reasoned as to make an epoch in the advance of mental science; and John Stuart Mill declared it to be "the finest example we possess of the psychological method in its full power."

Thus occupied in working out the laws of mental unfolding, it was impossible that Mr. Spencer's thoughts should not have been strongly attracted at this time to the subject of education. Descended from a race of schoolmasters, skillfully taught by his father and uncle on rational principles, and alive to the gross deficiencies of current teaching, he was predisposed to take an interest in all questions of mental cultivation. But the special direction of his studies now forced the subject upon him in a new and most important aspect. Education as a *leading out* of the faculties is essentially a problem of the growth of the faculties; and no new light could be thrown upon the processes and order of mental evolution without at once and powerfully affecting the practice of the art of education.

Spencer's "Education," produced at this period, was written from the point of view here indicated. It contains no formal statement of the evolution theory, but it conforms to the main doctrine throughout. The key-note and controlling idea of the book is, that Nature has a method of intellectual, moral, and physical development, which should afford the guiding principles of all teaching. The book is a plea for nature in education, and a protest against tutorial aggression, and meddlesome overdoing on the part of teachers and parents. The chapter on "Intellectual Education," which was written first and published in 1854, treats of school processes in relation to the law of development of the faculties as it takes place naturally. Education is regarded as rightly carried on only when it aids the process of self-development, and it is urged that the course of study in all cases followed should be from the simple to the complex, from the indefinite to the definite, from the concrete to the abstract, and from the empirical to the rational, in harmony with the course of evolution at large. In the chapter on "Moral Education" the subject is again regarded from the point of view of natural development. The general truth here insisted upon is, that the natural rewards and restraints of conduct are those which are most appropriate and effectual in modifying character. The principle contended for is that the moral education of every child should be regarded as an adaptation of its nature to the circumstances of life; and that, to become adapted to these circumstances, it must be allowed to come in contact with them; must be allowed to suffer the pains, and obtain the pleasures, which do, in the order of nature, follow certain kinds of action. "Physical Education" is again an argument from the biological side for the unhindered development of the bodily powers against the artificial restraints and repressions of school regulation; and it maintains that, during the earlier portion of life in which the main thing to be done is to grow and develop, our educational system is much too exacting. The last essay written, "What Knowledge is of Most Worth" (1859), is placed first in the volume, and is a vindication of the study of nature and the rightful supremacy of science in education. A memorable passage illustrates the change that must take place in the study of history when social phenomena come to be dealt with by the method of development.

Now, while, as we have already said, there is no formula of evolution in the book, and even the word occurs in it but rarely, yet Spencer's "Education" so entirely conforms to the doctrine, that, if it were rewritten to-day, it would hardly require revision in this respect. Mr. Spencer was, in fact, master of the new method at that time. If the reader will refer to the prospectus of Spencer's "System of Philosophy," which is prefixed to the volume, he will see how completely its author's views were matured, both in respect to the conditions, laws, and causes of evolution—the fundamental principles of the subject—and also of that detailed reconstruction of biological, psychological, sociological, and ethical science which evolutionary doctrine necessitates. The whole logical plan was traced out in its steps of dependence, and even in its proportions, with such singular accuracy, that he has hardly deviated from it in the twenty years subsequently devoted to its execution. The work on education was written while these views were taking definite shape in Mr. Spencer's mind, and half of it was written after his philosophical scheme was perfected. It was, of course, in advance of its time, and belonged to a stage of thought not yet reached either by the public mind generally, nor even in the enlightened circles of science. There was, as yet, but little talk of evolution, and when referred to it was generally derided by everybody as a vagary. Yet to Mr. Spencer's mind at this time evolution was not only a great truth, overwhelmingly demonstrated by concurring evidence from many sources, but it had become a principle of reorganization in large spheres of knowledge, and a new guide in the practical affairs of life. How thoroughly he had made the field his own, and how far in advance he was of even advanced thinkers, are sufficiently shown by the fact that, when Mr. Spencer tacitly based his treatment of education upon evolution doctrines which he had already wrought into an explicit and complete system, Mr. Darwin had, as yet, published nothing upon the subject.

We have here, unquestionably, one of the main causes of the success of this book. It anticipated and conformed to ideas that have since become widely popular. It has been increasingly appreciated because it has been found to harmonize with the striking results of advancing thought within the last twenty years. It has afforded trustworthy help in a time of transition when help is most urgently needed. Though a book of principles, it proved to be the most practical of educational manuals, because its principles were applicable to all circumstances, and it has become an authority because its indications have been attested by common sense, and verified as true by experience.

It is well, then, that we are to have a cheap edition of this instructive book, and all the better that it is in good print and in an attractive form. It ought to be extensively circulated among teachers and educational officials in this country, because, with our favorite system of State instruction, we are strongly inclining to the evils against which this book so powerfully protests. The machine-education of great school establishments is a system of external coercion which everywhere tends to thwart spontaneous natural development, and to hinder instead of facilitating self-education. It is the small minority of thinking persons in each country that has called for and commended Mr. Spencer's work; the great multitude of teachers know little of it. And, while as victims of a great mechanical system they are left but small liberty in the application of principles, and none at all of principles that contravene the official mechanics of the schoolroom, it is, nevertheless, desirable that they should be made to understand, as clearly as possible, the drawbacks of the system under which they work.

The extensive circulation of this book, both among teachers and parents, would be highly promotive of rational education; and liberally disposed people would do an effective philanthropic work by purchasing it at wholesale and donating it to those who are not familiar with its views.

It may not be improper to add, in these

times of wholesale piracy of the valuable works of foreign authors, that Mr. Spencer will continue to be paid by the publishers on this cheap edition of his "Education" just as he has been paid by them from the beginning on all his other publications.

New Departures in Collegiate Control and Culture. By Rev. Caleb Mills. New York: A. S. Barnes & Co. Pp. 50. Price, 30 cents.

The Rev. Caleb Mills, a graduate of Dartmouth College and of Andover Theological Seminary, was for forty years Professor of Greek at Wabash College, Indiana. He became the first Superintendent of Schools in that State, and so impressed his views upon its people as to earn the flattering title of "Father" of the Indiana common-school system. He died last October, and left this essay on the higher education as a last message to scholars and the people, and his friend Henry B. Carrington has seen it through the press in a very careless way.

The paper is mainly an argument on college methods with reference to alleged modern improvements in the studies and the management of these institutions. Mr. Mills clings tenaciously to the traditions, and strenuously resists all the new-fangled notions about optional studies and the introduction of modern languages, scientific branches, and practical knowledge into the collegiate curriculum. Only classics and the dead languages, he maintains, can give a liberal education, or that mental discipline which is the real object to be gained in all higher study.

Mr. Mills appears to think that it is the duty of colleges to go on to the end of time threshing the old Latin and Greek straw, although it has long since ceased to yield the grain that is commonly supposed to be the object of threshing. He seems, in fact, to think it a great point gained that the old dead straw no longer furnishes anything that can be utilized. Grain and bread and nourishment are sordid and vulgar things, which the thresher should no longer think of, and so the more empty and useless the husks the better. The real thing is the muscular exercise in the use of the flail, the noble discipline of his arms; for, when he has vigorously pounded the Greek and Latin litter for some years, he will get wonderful vigor for other forms of exercise.

Mr. Mills has various animated passages in denunciation of college reforms, but we can not see that he contributes anything important to the argument. The coolness with which he throws aside all modern knowledge, as of little or no account in higher education, is something surprising, and shows the havoc that forty years of Greek may make with a man's common sense.

Mr. Mills is greatly concerned about the use of the Bible as a college text-book; and the question of its more general employment in this way he declares to be "a live issue," which involves little less than the destinies of the nation. One of the bad signs of collegiate degeneracy is a neglect to use the Bible as a text-book. He informs us that reliable statistics show that "of forty-six colleges reporting, eighteen use it in a proper sense as a text-book and twenty-eight do not. Of twelve New England colleges, three use it and nine do not. Of twenty-two Western institutions, nine use it and thirteen do not give it a place in their curriculum."

Among the reasons for making the Bible a text-book in our colleges, Mr. Mills thinks that it would raise us in the estimation of the pagans, whose example in this respect he thinks it scandalous that we have failed to follow. He says: "Were an American Christian to go into the Mohammedan university at Cairo, with its ten thousand students, nothing there witnessed would impress him so deeply as the fact that so much time is occupied and so much attention given to the study of the Koran; and a like impression would be created were he to make a similar visit to a corresponding institution in the sacred city of Benares, and witness the exercises of that Brahmanical college, and listen to the lectures of its learned pundits on the Shasta literature and religion; if, then, returning to his native shores, he should make a corresponding exploration of some of *our* colleges, proud of their number of students and the spread of their curricula, and ask the venerable presidents thereof, Why has not the *Bible* place, if not a prominent one, at least a position, in your course of study? what reply would he receive?"

The Morals of Evolution. By M. J. Savage, author of "The Religion of Evolution." Boston: George H. Ellis. Pp. 191. Price, $1.

We congratulate Mr. Savage, first of all, on his standpoint in the treatment of moral questions. He has at once taken the advanced and unassailable ground that ethics is properly a branch of science to be investigated like all other kinds of knowledge, and that it forms no anomaly or sacred exception in relation to that common method by which truth of all kinds is sought and established. He is hampered by no restraints of authority in inquiring into the grounds and sanctions of right conduct, but discusses problems in the full freedom of reason and under the profound conviction that only in this way can an authoritative and well-based moral system ever be attained by man. And Mr. Savage uses his freedom with the best effect. He throws much light upon the practical aspects of the subject from the new point of view, and shows the adequacy of the canons of natural morality for guidance in the conduct of life. He makes no claim to work out a rigorous ethical scheme, but contents himself with a popular exposition of the principles of right and wrong action as they are affected by the progress of knowledge and those new views of the nature of man which evolution has forced upon the attention of the world. His style is familiar, his illustrations apposite, and his reasoning clear and forcible. His book will be found helpful and instructive to many minds, and the same thing may be said of the course of liberal sermons which he has delivered from the Unity pulpit in Boston, and which are printed as a series of neat tracts. The contents of the present volume at first took this form of pulpit discourses; and it is encouraging that at least one large congregation has been found sufficiently intelligent and liberal not only to tolerate, but to accept and appreciate them.

Brain and Mind; or, Mental Science considered in Accordance with the Principles of Phrenology, and in Relation to Modern Physiology. By Henry S. Drayton, A. M., and James McNeill. New York: S. R. Wells & Co. 1880. Pp. 334. Price, $1.50.

The authors here give a restatement of phrenology, with a great many cuts of heads, and a claim that the phrenological system has been affiliated upon the principles of the later physiology. It is generally considered that the results of the most modern researches into the nervous system contravene phrenological doctrine as formerly expounded. How far they are capable of reconciliation we will not undertake to say, but if anybody is interested, and will get this book, he will be in possession of perhaps the latest attempt at harmonization.

Sea-Sickness. By George M. Beard, A. M., M. D. New York: E. B. Treat & Co. 1880. Pp. 74. Price, 50 cents.

In this little work Dr. Beard has made a careful study of this distressing malady, and advances a theory of its nature, which, he claims, harmonizes with all the facts, and a mode of treatment which is effective. He holds that it is a "functional disease of the central nervous system, mainly of the brain, but in some cases of the spinal cord also." The symptoms, which he says have never been before clearly described, he gives as headache, backache, nausea without vomiting, vomiting, pain in the eyes, constipation and diarrhœa, menstrual suppression, hopelessness and mental depression, temporary abnormal appetite, neuralgic pains, chilliness with flashes of heat, sleeplessness, and nervous exhaustion. These symptoms are all due to the agitation of the nervous system by the motion of the ship. This view of the disease is quite at variance with the popular and even professional one, which has regarded it as an affection of the stomach and digestive apparatus. Among the considerations brought forward by Dr. Beard in support of his view is the fact that the very young and the very old are seldom or never troubled with it. "It is," he says, "the disease of active cerebral life, between fifteen and sixty-five," being in this respect like sick-headache, which we now know to be a nervous affection. In further support of this theory, observation shows the delicate, finely-organized, and nervous to be more liable to sea-sickness than the strong and phlegmatic. The treatment advocated by Dr. Beard is based upon this view of the nervous character of the disease. It consists in giving such remedies before and during the attack as will reduce the sensitiveness of the central nervous system. He has given his treatment extensive trial, and avers that it has rarely failed. The remedy he has found best of any is the bromide of sodium in doses of thirty to sixty grains, three times a day for several days before starting, and during the voyage, until all danger is past. The remedy should at first be administered by a physician, and can afterward be intrusted to the patient. Dr. Beard especially warns against the use of purgatives, spirituous liquors, and morphine or opium. With the bromine-treatment he states that the patient may remain on deck or in his state-room indifferently, and may eat such things as he may desire. He is also much less liable to take cold at sea or just after landing.

The Throat and its Functions. By Louis Elsberg, A. M., M. D. New York: G. P. Putnam's Sons. 1880. Pp. 60. Price, $1.

This is one of the popular scientific lectures given under the auspices of the New York Academy of Sciences, and the subject, as befits such a course, is treated in a manner to make it clear to the unscientific. Dr. Elsberg describes the various parts of the throat and their function in speaking, and some of the instruments used in examinations of the throat, and closes his lecture with a description of Edison's phonograph, which he exhibited to his audience.

Alva Vine; or, Art versus Duty. By Henri Gordon. American News Company. Pp. 233.

This is a sketch, a fancy sketch, of what the author calls "a suggestive woman of the republic — a girl with a good *physique*, a cultivated mind, a large heart, capable of taking an interest in all that appertains to the welfare of the whole human family." It is a *very* fancy sketch.

A Study of some of the Starches. By Mrs. Lou Reed Stowell, M. S., Microscopical Laboratory, University of Michigan. Ann Arbor, Michigan: Courier Steam Printing-House. 1880. Pp. 17. Price, 15 cents.

This is a brief description of the appearance under the microscope of some of the more common starches, with instructions how to study them. The starches considered are those of potato, arrowroot, wheat, barley, bean, pea, corn, rice, oat, buckwheat, sago, tapioca, turmeric, and ginger.

The Management of Children, in Sickness and in Health: A Book for Mothers. By Annie E. Hale, M. D. Philadelphia: Presley Blakiston. Pp. 110. Price, 50 cents.

No better fifty cents' worth of a book for mothers have we seen in a long time. It is full of just the kind of information that all mothers require to possess, and this information is imparted in a simple and sensible manner, so that it may be perfectly understood. The points of most importance are given emphatic prominence, and the subjects are treated throughout with excellent judgment. It is one of the little manuals that can not be too strongly commended.

Problems in Relation to the Prevention of Disease. By J. R. Weist, A. M., M. D. Richmond, Indiana: Telegram Printing Co. 1880.

This is the address of the President of the Indiana State Medical Society at its session of this year. Dr. Weist points out the great losses, commercial and other, that result from an ignorance and disregard of sanitary conditions, and insists upon the necessity of legislation in the matter. He contends that the aim of physicians must be more and more to prevent rather than cure disease, and urges the consideration by them of such problems as have direct bearing upon public hygiene, a number of which he briefly indicates.

The Problems of Insanity. A Paper read before the New York Medico-Legal Society, March 3, 1880. By George M. Beard, A. M., M. D.

Dr. Beard declares, probably with much truth, that psychology is to be the great absorbing study of the future, and, in the study of the human mind, a thorough understanding of insanity will not only be of the greatest help, but indispensable. Among the problems he indicates as demanding attention are the proper definition of the disease, the general causes of it and of its increase in modern life, its real or apparent increase among the poorer classes, its diagnosis, and the proper system of treating it. In considering its increase Dr. Beard points out as fruitful in results the increased friction of modern life, especially in the sphere of emotion, reaching the conclusion that the increase is "not so much among the most intellectual as among the least intellectual and highly emotional classes of civilization." The essay is throughout suggestive and well worth perusal by those interested in one of the most important fields of scientific investigation.

New Characters of Mosasauroid Reptiles. By Professor O. C. Marsh. Reprint from "The American Journal of Science." Illustrated.

The remains of mosasauroid reptiles, though first discovered in Europe, were of such rare occurrence as to offer only limited opportunities for study; but they have been found in abundance in this country, and the Museum of Yale College alone has a collection containing some fourteen hundred distinct individuals, representing several families and numerous genera and species. This profusion has enabled Professor Marsh to make a very thorough examination of the group, and he has been rewarded by the discovery of several new characters, the more prominent among them being the presence of a sternum probably common to all the forms, the possession of posterior limbs, and of hyoid bones.

Bulletins 1, 2, 3 (Vol. V.), of the United States Geological and Geographical Survey of the Territories. Washington: Government Printing-Office. 1879.

These numbers make a volume of five hundred and twenty pages, comprising twenty-five articles, giving results of original work in the natural history, geography, physical features and resources of a portion of our Western Territories. Among others, Professors Riley, Cope, and White, Dr. Coues, Dr. Le Conte, and Mr. Henry Gannett, have each contributed to the volume.

A Guide to Modern English History. By William Cory. Part I., 1815–1830. New York: Henry Holt & Co. Pp. 269. Price, $2.

This book, the author says, has grown out of an attempt made a few years ago to give some account of English politics to a foreign guest, who was not a Christian or a European, but who at the time was reading English history for examination. Without attempting to adhere to the plan of adapting statements to so remote a mind, the author has thought it good to explain many terms which in ordinary books are assumed to be understood; and he has done it very successfully, in a plain, pleasant style, under the form of a running review of the principal events and political movements of the period embraced.

Introduction to the Study of Sign-Languages among the North American Indians, as illustrating the Gesture-Speech of Mankind. By Garrick Mallery, Brevet Lieutenant-Colonel United States Army. Issued by the Smithsonian Institution, Bureau of Ethnology, Washington, 1880.

This is the second of an important series of papers on American ethnology; the first, issued some time since, being an "Introduction to the Study of Indian Languages," by Professor J. W. Powell. A third is to follow on "Mortuary Observances and Beliefs concerning the Dead," by Dr. H. C. Yarrow, of the United States Army.

The study of anthropology is growing rapidly in importance and interest in this country. Vast collections of whatever may illustrate it are being made, and these thoroughly scientific papers will facilitate and direct the work. They are among the most valuable issued by the Smithsonian Institution.

Camps and Tramps in the Adirondacks, and Grayling Fishing in Northern Michigan: A Record of Summer Vacations in the Wilderness. By A. Judd Northrup, Syracuse, New York: Davis, Bardeen & Co.; New York: Baker, Pratt & Co. 1880. Pp. 302. Price, $1.25.

The author has undertaken in this little volume to describe his life in the woods, his adventures and talks, exactly as they occurred, without invention or exaggeration, and to give truthful pictures of actual summer life in the Adirondacks. By introducing the companions of his journeys, actual men of education and refinement, but who left the shop and the school behind them for a holiday, he has made his story an entertaining one.

Annual Report of the Wisconsin Geological Survey for 1879. By J. C. Chamberlin, Chief Geologist. Madison, Wisconsin: State Printer, 1880.

We learn from this brief report that the work of the survey is approaching completion. Two volumes of the reports are now in the printer's hands; and a third, which, however, will be Vol. I. of the series, will shortly follow, and will be devoted to the general geology of the State.

Deutsch-Amerikanische Apotheker-Zeitung. Edited by Dr. George W. Rachel, and published by the Pharmaceutical Publishing Company, 5 Gold Street, New York. Pp. 16. Illustrated. Price, $2.50 a year.

"The Deutsch-Amerikanische Apotheker Zeitung" (German-American Druggists' Gazette) is a semi-monthly journal which has been started in the interest and as the organ of the German apothecaries, chemists, and physicians, of the United States. It promises original articles and correspondence from writers of recognized standing in their respective fields, notices and reviews of all that is new in the branches of science to which it is devoted, for which the American and European press will be consulted, market reports of drugs and chemicals, and free discussions. The numbers before us are filled with articles and paragraphs of scientific merit, comprehensive in scope, varied in character, and abreast with the times.

Silver in its Relation to Industry and Trade: The Danger of demonetizing it. The United States Monetary Commission of 1876: Review of Professor Francis Bowen's Minority Report. By William Brown. Montreal: Printed by the Lovell Printing and Publishing Company. 1880. Pp. 134. Price, 60 cents.

The purpose of this work is to present the arguments in favor of retaining silver money—"the money of industry," as the author calls it—in such a manner that they shall be plain to ordinary minds, and that interest in the discussions on the subject shall be shared by the people at large.

The "Naturhistorische Verein für Wisconsin," which has existed as an unincorporated society in the city of Milwaukee for twenty-two years, has been incorporated as the Natural History Society of Wisconsin, for the purpose of investigating the facts pertaining to the natural history and ethnology of the State. Its first year's report, in the German language, contains notices of the papers read at the several meetings of the Society, and an essay on "Life on the Prairie," by Dr. Emil Ulrici. Dr. Ulrici also sends us a paper (in German), of which he is the author, on "the settlements of the Normans in Iceland, Greenland, and North America, in the ninth, tenth, and eleventh centuries."

PUBLICATIONS RECEIVED.

Diagram of the Progress of the Anthracite Coal Trade of Pennsylvania. With Statistical Tables, etc. By the Messrs. Sheafer. Pottsville, Pa. 1879.

On Fluid Extracts as prepared for the Coming Pharmacopœia. Detroit. 1880. Pp. 7.

Photometric Researches. By William H. Pickering. Cambridge: John Wilson & Son. 1880. Pp. 14.

Therapeutic Action of Mercury, pp. 27, and Mechanical Therapeutics, Chemistry, and Toxicology of Mercury, pp. 19. By S. V. Clevenger, M. D. Chicago. 1880.

The Felsites and their Associated Rocks north of Boston. By J. S. Diller. Pp. 13.

High Schools. By B. G. Northrop. Syracuse: Davis, Bardeen & Co. 1880. Pp. 26. 25 cents.

The School Bulletin Year-Book for 1880. An Educational Directory of the State of New York. Compiled by C. W. Bardeen. Syracuse: Davis, Bardeen & Co. 1880. Pp. 36, with Map. $1.

Memoirs of the Science Department, University of Tokio, Japan. Vol. II. On Mining and Mines in Japan. By C. Netto, M. E. Tokio: Published by the University. 1879. Pp. 54. Illustrated.

On the Ethers of Uric Acid. Second Paper. Dimethyluric Acid. By H. B. Hill and C. F. Mabery. From "Proceedings of the American Academy." Pp. 11.

The "American Journal of Philology." Edited by Basil L. Gildersleeve. Vol. I., No 2. Baltimore: The Editor, May, 1880. Pp. 126. Quarterly. $1 per number, or $3 a year.

Bromide of Ethyl as an Anæsthetic. By J. Marion Sims, M. D., LL. D. Read before the New York Academy of Medicine, March 19, 1880. Pp. 22.

A Defense of Free Thought, together with a Theory of the Origin of Morals and Religion, and some Speculations on Immortality. By an Agnostic. Galveston, Texas. 1880. Pp. 52.

Annual Report upon the Surveys of the Northern and Northwestern Lakes, and the Mississippi River, in charge of C. B. Comstock. Washington: Government Printing-Office. 1879. Pp. 180.

The Fifty-sixth Annual Report of the Officers of the Retreat for the Insane at Hartford, Conn. Hartford. 1880. Pp. 36.

Hearing by the Aid of Tissue Conduction. The Mouth-Trumpet and the Audiphone. By Samuel Sexton, M. D. New York. 1880. Pp. 8.

Researches on Hearing through the Medium of the Teeth and Cranial Bones. Reprinted from the "Philadelphia Medical Times." Pp. 4. And The Perimetric Dimension System. A General System of Measurement for Urethral, Uterine, Rectal, and other Instruments, and an Adaptable Metric Gauge. By Charles H. Thomas, M. D. Philadelphia. Pp. 4.

Percy's Pocket Dictionary of Coney Island. With Map and Illustrations. New York: F. Leypoldt. 1880. Pp. 120. 10 cents.

Graded Selections for Memorizing. By John B. Peaslee, A. M., Ph. D. Cincinnati and New York: Van Antwerp, Bragg & Co. Pp. 192. 50 cents.

The Liberal Hymn-Book. Edited by Eliza Boardman Burnz. New York: Burnz & Co. 1880. 25 cents.

University of Tokio. The Calendar of the Departments of Law, Science, and Literature. 1879-'80. Tokio: Z. P. Maruya & Co. Pp. 163.

Some Thoughts concerning Education. By John Locke. With Introduction and Notes. By the Rev. R. H. Quick, M. D. London: Cambridge Warehouse. 1880. Pp. 140. 90 cents.

Annual Report of the Chief Engineer of the Water Department of the City of Philadelphia for the Year 1879. Philadelphia. 1880. Pp. 100.

The Principles of Nature, etc. Also an Exposition of the Spiritual Universe. Given inspirationally. By Mrs. Maria M. King. Vols. II. and III. Hammonton, N. J.: A. J. King. 1880. Pp. 261 and 268. $1.75 per vol.

POPULAR MISCELLANY.

The Catskill Mountains.—Professor A. Guyot gives, in the "American Journal of Science" for June, the results and a map of the first scientific survey of the Catskill Mountains, which he has undertaken, and with the aid of interested assistants has so far successfully carried out. These mountains, though situated in the most populous and civilized part of the United States, and visited every year by thousands, are among the least known in our country. Yet several features of the group are well calculated to excite the curiosity of the scientific investigator, and to call for a thorough study of its plastic forms. Though a part of the Appalachian system, the range appears in it as an anomaly; for, while the other Appalachian ranges trend from the southwest to the northeast, the Catskills run at right angles to them, or from the southeast to the northwest. The Catskills also surpass all the neighboring ranges of mountains by two thousand feet of height. Professor Guyot has devoted the summer vacations of seventeen years to their examination. His map represents a surface of about four thousand square miles, of which the mountainous part proper occupies somewhat more than one half, or about twenty-four hundred square miles. The distances and bearings are computed from the points of the triangulation of the Coast Survey along the Hudson River as a base. The mountain region is divided by the Esopus Creek into two groups, differing considerably in their physical structure, the northern, or Catskills proper, and the southern Catskills or Shandaken Mountains. "The northern group, or Catskills proper, between the Esopus and Catskill Creeks, form a massive plateau having the shape of an irregular parallelogram, extending from southeast to northwest, and shut up between two high border chains, ten or fifteen miles distant from each other, running about in the same direction. The southwest border is formed by what may be called the central chain of all the Catskills, the other by the northeast border chain. The southeast end is closed by the short chain of the High Peak; the northwestern by the high swell of plateaus which divide the head-waters of the Delaware and Susquehanna from those of the Schoharie Creek and the Hudson. Inside of this highland, three secondary ranges, starting from the northeast border chain and running nearly west, almost to the foot of the central chain, fill the inner space, inclosing deep valleys in which flow the waters of the Schoharie Creek and its tributaries. . . . A striking peculiarity of the plastic forms of the northern Catskill group is, that while its western end is, as it were, buried in the general plateaus of western New York, its mountains rising but moderately above their surrounding base, its eastern end stands isolated on three sides by deep and broadly open valleys, projecting, in all its height, as a mighty promontory, to within ten miles of tide-water in the Hudson River." The very base of its mountains rarely exceeds six hundred feet above tide. "No wonder, then," says Professor Guyot, "that the aspect of the Catskills is nowhere more imposing than from the Hudson River and the surrounding lowlands, from which their whole height is seized at a glance, and that it has been thus far believed that the highest points were found among the mountains of the eastern end." The panorama of the mountains, as seen from Catskill village, is not a view of a single chain, but takes the eastern end of the border chains and the short range bearing the High Peak, which rises between the two. The Catskills do not present prominent examples of anticlinal and synclinal folds or arches, or fragments of arches, as in ordinary mountain-chains, but are masses of piled-up strata, seldom deviating notably from their original horizontal position. On account of this disposition of the strata, and their tendency to break at right angles to the planes of stratification, they are marked by the frequent abrupt ledges which are peculiar to them. For the same reason, the tops of the mountains are not pointed peaks, but are mostly flat surfaces, often of considerable extent. The central chain is the longest and most massive of the series, and is the backbone of the whole Catskill region. From Overlook Mountain to the Utsyantha, near Stamford, it is a little more than thirty-five miles long, and is divided into four almost equal parts by three deep gorges or cloves. The heights increase regularly from the Overlook to Hunter Mountain, one quarter of the way back, which, 4,038 feet high, is the highest point of the northern Catskills, overtopping High Peak, which has borne that name, by nearly four hundred feet. From this point the heights diminish to the Utsyantha, at the western end of the chain, whose height, 3,205 feet, is not greatly different from that of Overlook, 3,150 feet. The High Peak range, which is sandwiched between this range and the northern range, is only six miles long, and is distinguished by its High Peak, 3,664 feet high. The northeast border chain begins at South Mountain, near the Catskill Mountain House, which is 2,497 feet high, culminates at Black Dome, 4,003 feet high, and ends at Leonard Hill, 2,649 feet high, showing a similar rapid rise for a quarter of the distance, and a gradual fall toward the western end with the central range. The highland between these two chains, an irregular parallelogram twenty-seven miles long and from six to fifteen miles wide, is filled by three ranges, which are separated by valleys in which flow the tributaries of Schoharie Creek. This stream and its tributaries furnish the entire drainage for the interior highlands of the Catskills proper. The streams that run directly to the Hudson draw no water from the interior, but belong properly to the outside slopes. "This drainage, which sends the waters of the Catskills all the way around to the Mohawk to come back by the Hudson, after a course of one hundred and seventy-five miles, to within ten miles of their starting-point, is certainly remarkable, and betokens a very peculiar physical structure. This is made more striking by the fact that on both sides of these highlands the waters of the valleys of the Catskill and Esopus Creeks flow, as we might have expected, from the western plateaus directly to the Hudson River. The nearly horizontal position of the strata, which is common to the mountains and the surrounding plateau, and the peculiar features of the drainage, lead to the inference that the plastic forms of the Catskill region are the work of erosive forces, and are not due to the ordinary dynamic process which has folded and shaped the other parts of the Appalachian system. "We may, therefore, conceive the original form of the Catskills to have been that of a high plateau, a mass of elevations forming a part of the Appalachian plateau region which extends west of the Alleghanies from south Virginia, and fills nearly all the western portion of the State of New York south of Lake Ontario and the Mohawk River. The lowest altitude of the primitive plateau is marked by the ideal plane which would pass through the mountain-tops, and its superior elevation on the east would account for the flow of the waters, the gradual scooping out and the sloping of the valleys in the direction they now have." The southern Catskills have not the regular features which characterize the northern group; the boundaries are not well defined, except along the Esopus Valley; and, instead of their having an interior plateau inclosed by high border chains, the massive central chain, which bears the highest summit, is accessible from all the surrounding valleys without crossing any high pass. Their general direction is about the same as that of the northern Catskills, but several important ridges run at right angles to this direction, and impart considerable physical irregularity to their structure. The Slide Mountain, the culminating point of this group, is the highest of all the Catskills, measuring 4,205 feet, and is the hydrographic center of the region, whence the waters run to the northwest by the Esopus, to the northeast by Woodland Creek, to the south by the Rondout to the Hudson, and to the southwest by the Nevisink to the Delaware. The geological structure of the group is similar to that of the northern Catskills. Professor James Hall has announced that, after four years of observation, he has detected the existence of four lines of anticlinals, nearly parallel to each other, and running from southwest to northeast, in conformity with the ordinary trend of the Appalachian range. Professor Guyot is willing to acknowledge the fact, but calls attention to the other fact that these axes cross the chains and valleys almost at right angles, "and were probably posterior to the scooping out of the valleys and mountain-chains, on the conformation of which they had so little effect. . . . A hypsometric feature, which may refer to this order of facts, is that the three maxima of altitudes above four thousand feet, the Slide Mountain, Hunter Mountain, and Black Dome, are situated in a straight line, trending from southwest to northeast."

Silicified Forests of the Yellowstone Park.—In Bulletin No. 1 of Vol. V. of the "Geological and Geographical Survey of the Territories," Mr. W. H. Holmes gives an account of a most wonderful geological formation, which attains its greatest development in the valley of the east fork of the Yellowstone River. It occurs in horizontal layers, having an aggregate thickness of fifty-five hundred feet, that is, the whole formation at this point is a little more than a mile in depth. This is filled throughout with the silicified remains of a multitude of forests, many of the trunks of trees that are still to be seen being of very large size. Some of them are prostrate, and from fifty to sixty feet long; others are upright where they grew, and some of the stumps measure from five to six feet in diameter. One gigantic trunk is described that stands twelve feet above the eroded strata about it, and is ten feet in diameter. This trunk is hollow, but the woody structure of what remains is well preserved, the rings of growth being clearly defined. The bark on this stump is four inches thick, and on its outer surface deeply lined. Scattered through the formations among the trunks is a great variety of vegetable remains, consisting of branches, rootlets, fruit, and leaves. Specimens submitted to Professor Leo Lesquereaux have been identified as follows: Aralia Whitneyi, Magnolia lanceolata, Laurus Canariensis, also new species of Fraxinus, Cornus Alnus, Tilia, Diospyros, Pteris, and Fern. The wood is in many cases completely agatized, and cavities which existed in the decayed trunks are filled with crystals of calcite and quartz. The formations are of the "Volcanic Tertiary," and composed of fragmentary volcanic products, breccias, conglomerates, and sandstones, the two former consisting chiefly of basalt. Many are of great size, and are cemented together in enormous masses or heavy beds by tufaceous and other fine-grained material. These beds or layers represent successive formations, arising from the subsidence of the land, during the intermissions of which the forests grew. The beds have evidently been changed by the action of water; and the conclusion is that the formation represents the shore or margin of a great Tertiary lake. It is believed that the beds cover or have covered an area of over ten thousand square miles.

Germs of Disease in Water.—Professor Huxley, in a recent discussion of a paper by Dr. Tidy on water for dietetic purposes, said that diseases caused by what people not wisely call germs are produced invariably by bodies of the nature of bacteria. These bodies could be cultivated through twenty or thirty generations, and then, when given under the requisite conditions, would invariably cause their characteristic disease. Bacteria are plants, and we know under what conditions they can live and what they will do. They can be sown and will thrive in Pasteur's solution, just as cress or mustard in the soil; and, if a drop of this solution were placed in a gallon of water, Professor Roscoe thinks it doubtful if there is any known method by which its constituents could be estimated. Every cubic inch of such water would contain fifty thousand to one hundred thousand bacteria, and one drop of it would be capable of exciting a putrefactive fermentation in any substance capable of undergoing that fermentation. The human body may be considered as such a substance, and we may conceive of a water containing such organisms which may be as pure as can be as regards chemical analysis, and yet be, as regards the human body, as deadly as prussic acid. This is a terrible conclusion, but it is true; and, if the public are guided by percentages alone, they may often be led astray. The real value of a determination of the quantity of organic impurity in a water is that by it a shrewd notion can be obtained as to what has had access to that water. If it be proved that sewage has been mixed with it, there is a very great chance that the excreta of some diseased person may be there also. On the other hand, water may be chemically gross, and yet do harm to no one, the great danger being in the disease-germs.

Man in America.—Professor Flower, in a recent lecture on the "Anatomy of Man," before the Royal College of Surgeons, London, discussed at some length the question of his origin on the American Continent. Till recently, opinions on the early peopling of America had been divided between the views that the inhabitants of this continent were a distinct indigenous people, and therefore not related to those of any other land; and that they were descended from an Asiatic people who, in comparatively recent times, passed into America by the way of Behring Strait, and thence spread gradually over the whole Continent. These theories have had to undergo considerable modifications in consequence of the discovery of the great antiquity of the human race in America, as well as in the Old World. The proof of this antiquity rests upon the high and independent state of civilization which had been attained by the Mexicans and Peruvians at the time of the Spanish conquest, and the evidence that that civilization had been preceded by several other stages of culture, following in succession through a great stretch of time. The antiquity of this quasi-historical period is, however, entirely thrown into the shade by the evidence now accumulating from various parts of North and South America, that man existed on the Western Continent, and under much the same conditions of life, using precisely similar weapons and tools, as in Europe during the Pleistocene or Quaternary period, and perhaps even farther back in time. Recent paleontological investigations show that an immense number of forms of terrestrial animals, that were formerly supposed to be peculiar to the Old World, are abundant in the New. Taking all circumstances into consideration, it is quite as likely that Asiatic man may have been derived from America as the reverse, or both may have had their source in a common center, in some region of the earth now covered with sea.

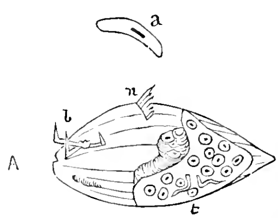
Illusions and Apparitions.—All illusive visions and apparitions are susceptible of a scientific explanation. They originate in some derangement of the brain and nervous system, and are for that reason most likely to occur to persons who are out of health. The apparent reality of some of these illusions is often wonderful, and might well prompt those who are not acquainted with nervous physiology, or who have not devoted careful attention to the subject, to refer them to something out of the common. Even while we are in perfect possession of our faculties, we imagine that we see objects before us as clearly as though they were actually present, or hear, with equal distinctness, sounds which have no real existence outside of ourselves. The explanation may be found in a simple study of the physiology of the nervous system, and shows that the illusions have a material basis. Our sensations are transmitted from the organ that receiyes them to the brain, and it is the brain, not the organ, that experiences them and is their seat. In the case of sight, it is the function of the eye to receive and adjust the rays of light coming from the object that we see, so that they shall produce an impression on the brain. The eye represents the lenses of the photographer's camera; but the brain corresponds to the sensitive plate which receives the image, and on which all subsequent alterations of the image are effected. Similar relative parts are played by the organs and the brain in the case of the other senses. Now, if a similar impression to that which is transmitted to the brain from the organ of sense is produced upon it by any other cause, the same kind of a sensation will result. This may happen when the brain is in an excitable or irritable state from ill health or any other cause, and is enough to explain all the phenomena under consideration. The visions most often correspond to our previous experiences, and therefore represent objects we know. Sometimes, however, the images are unfamiliar, and they are then referred to objects that we have seen, but have ceased to remember in our natural condition. The apparitions are thus explained as the creatures of our imagination, which, through some brain-disturbance, is enabled to project its visions forward on the seats of sense, just as the ringing in the ears, with which we are all familiar, is produced by some irritation of the hearing-center of the brain.

Soils as Filters.—Dr. Victor C. Vaughan, of the University of Michigan, has described in "The Sanitarian" some experiments which he has made to determine the power of soils to prevent the filtration of organic matter in solution. They had reference to the questions, To what extent are organic substances removed from solution by filtration through the soil; and do different soils differ in their capability of thus removing organic matter? Urea was selected as the substance with which the experiments should be tried, and urine as the fluid with which filtration should be performed. The ordinary gravel soil of Michigan was found to produce but little effect in detaining the urea, while it soon became saturated; and the conclusion was drawn that the secretions from a family of six persons each day would be sufficient, when properly dissolved, to saturate more than seven cubic feet of this soil, and that only a few weeks or months would suffice, with a proper amount of rainfall, to saturate every cubic foot of soil to the depth of five or ten feet in a small yard. Gravel, however, is the poorest of filters, for the spaces between the particles allow the liquid to run through freely at certain points. Sand and loam exhibited a more satisfactory action, the loam more so than the sand, both these substances receiving a perceptibly larger quantity of urea before they were saturated. This is probably owing partly to their greater uniformity of constitution, in consequence of which water can not run as fast through them as through gravel, and partly to their greater porosity, by means of which matter passing through them is more closely exposed to the action of oxygen, the most efficient agent for the destruction of organic impurities.

Freezing of a Lake by Radiation.—A remarkable instance of the freezing of water in consequence of the radiation of heat was remarked in the Lake of Morat, Switzerland, after the cold weather of March last. The lake, of which three fifths of the surface had been covered with ice, was clear on the 8th of March, and the weather had become warm. During the night of the 10th of March, the thermometer did not descend to the freezing-point; yet on the morning of the 11th the lake was covered over with a thin sheet of ice. The Lakes of Neufchâtel and Constance were similarly covered. The freezing is accounted for by supposing it to have been occasioned by the rapid and great radiation of heat which took place on a perfectly clear night. An intense degree of cold had been necessary to cause the lakes to freeze during the cloudy weather of the previous cold spell, and the freezing was then very irregular and unequal.

Effects of Diseased Meat.—Mr. Julius Hardwicke, F. R. C. S., an English local medical officer of health, recently read a paper at a sanitary meeting on "Meat as Food for Man," in which he considered the effects of diseased meat on the human system. The evidence on this subject is of the most conflicting character. According to Dr. Letheby, enormous numbers of animals that died of rinderpest in 1863, and more recently of pleuro-pneumonia, have been sent to the London market and eaten without having produced any tangible effects; the Scotch eat "braxy" mutton with impunity, and, some say, even prefer it to sound mutton; and the people of Paris must have eaten much diseased meat during the siege, though we have no account of their having suffered from the effects of it. The symptoms or complaints of those supposed to be suffering from having eaten diseased meat are very similar to those occasioned by the use of putrid meat. Parasitic disease is quite different. Dr. Parkes names as the diseases of cattle that should be watched for: Pleuro-pneumonia, foot-and-mouth disease; cattle-plague, or rinderpest; anthrax, or malignant pustule; simple inflammatory affections of the lungs; dropsical affections from kidney or heart disease; indigestion with apoplectic symptoms. The first three are described as contagious, and the last three as sporadic diseases, in a work by Professor Williams, of Edinburgh. To this list Mr. Hardwicke adds, as contagious, glanders and farcy (which may be communicated to consumers of horse-meat), puerperal apoplexy, and variola. He also adds a list of epizoötic diseases, meaning diseases occasioned by parasites, including measles in the pig; rot, or fluke disease, in sheep; gid, turn-sick, or staggers, in sheep; phthisis, or hoore, in cows, pigs, and poultry (gapes). The diseases of sheep are similar to those of cattle. They are subject to small-pox, malignant pustule, a parasitic chronic lung affection, and braxy or splenic apoplexy. Pigs are subject to anthrax, typhoid, and hog-cholera. The contagious diseases are communicable by contact, by inoculation, and by infection. Hence it is not safe to let any of these classes of diseased meat go forth to the public as fit for consumption. To the opinion that cooking will destroy the contagious property and render the food fit for use, Mr. Hardwicke replies that there is no proof of it. Meat subjected to a temperature of 160°, which it is thought will thoroughly cook it, may still be productive of disease by inoculation. We are yet ignorant of the nature of the contagious property, and, if it be a living germ, what proof have we that, even if we succeed in destroying this germ and the entozoön of parasitic disease, a possible potent matter produced by the germ or ova of entozoön may not still exist and possess infective qualities?

The Milky Sea.—The peculiar coloration which has given the name of the milky sea to certain regions of the ocean has been remarked by many sailors, but a diversity of opinion has been expressed as to the cause of the phenomenon. Some have attributed it to electric action taking place during the hours preceding a storm; others to chemical combinations resulting from the decomposition of the bodies of marine animals and plants, and producing phosphorescence; others to spawn deposited on the surface of the water, which is supposed to be made to shine by the moving of masses of fish through it. None of these hypotheses have been confirmed, but they have all been contradicted by positive evidence that the milky sea is produced by a prodigious accumulation of animalcules, capable of becoming phosphorescent spontaneously, or of being made so by friction. The most recent and decisive evidence in this direction was observed on board the French ironclad Armida, on her recent voyage from Japan, while crossing from Point-de-Galle to Aden. At about half-past twelve in the morning of the 10th of February, 1880, the sky being clear, with no moon, the western part of the horizon, toward which the ship was going, became so bright as to attract the attention of the officer of the quarter. He at first thought the light was occasioned by the numerous bright stars which were about setting, but the increase of the light caused him to change his opinion, and he concluded that it was from a ship on fire. A half hour afterward a layer of whitish foam appeared covering the water for a considerable extent. The whole sea, shining with a milky luster as brightly as the usual phosphorescence which a ship produces in its passage through the water, resembled a field of snow in a clear night. It shone enough to efface all traces of the undulations of the swell; the waves could not be distinguished; and the sea seemed as flat and even as in a calm. The wake of the ship (which is generally visible for two or three miles back), and the disturbance of the water by the screw were hardly marked on the still surface. These facts proved that the luminous coating was not merely superficial, but that it had a considerable thickness. The phenomenon became more marked and intense, and one observing it might have believed he was locked in a sea of ice, had there been no movement of the ship to undeceive him. By daylight all had disappeared. On looking closely at the water as it rippled along the ship, there were noticed a great quantity of luminous particles pressed closely one upon another, the most brilliant ones being those which had been in contact with the bottom. The water when taken up in a bucket appeared to be full of phosphorescent bodies, from a half to three quarters of an inch long, which sparkled when they were brushed about by the hand. Nearly four hundred of them were counted in a bucket holding ten quarts. When taken from the water and examined by the light of a lamp, they were seen to be formed of a gelatinous substance which dried up quickly in the air and disappeared, leaving a dark globule a millimetre in diameter (see figure), which could be made lively again, and capable of becoming luminous, by putting a drop of water upon it. When rubbed in the hand, the bodies left a bright train which soon went out, leaving no odor. The globules under the compound microscope were transparent, filled with eggs of an ovoid shape, and were continually agitating their fins and tentacles. The organism is ellipsoid-



A Phosphorescent Animalcule of the Milky Sea (natural size). A the dark globule seen in the center of *a* magnified.

al and full of eggs, which are contained in an internal sac; the internal tentacles, *t*, always in motion, keep the eggs in circulation. The exterior tentacles, *b*, have a motion like that which we make in stretching out the arms, drawing them back and bending the elbows. The object marked *n* is a comb-shaped fin, with twelve or fifteen bones. The epidermis is striated in the direction of the major axis of the ellipse. When kept till daylight and examined in a dark room, the water gave no light; it was of no use to shake or stir it, the bodies had lost their phosphorescent property. Fresh water, drawn up in the daytime and stirred in the dark, likewise showed no phosphorescence, although the color of the waters, a dirty-blue bordering upon gray, indicated that the ship was still close to the milky sea. On the next evening the milky tint came on again, all at once, at about seven o'clock, an hour and twenty minutes after sunset and an hour after dark. The beautiful appearances of the preceding night were again observed, but the whitish reflection in the horizon more resembled a fog which obscured it and made it seem nearer. Drops of water examined by themselves in the microscope revealed filaments of marine plants and numerous proliferous vegetable cells. The animalcules were the same as before, and were the only luminous objects. The nights of the 9th, 10th, 12th, and 13th of February were thus adorned with the splendor of the milky sea; during this time the ship had passed through six hundred and sixty miles, or two hundred and twenty marine leagues, in a mean latitude of 12° north, between the sixty-first and fifty-first meridians of east longitude. The atmosphere was in its normal condition, as was also the sea; the moon was new, the sky was clear, the barometer and thermometer were steady. No storm was near; no change was observed in the hydrometric condition of the air; the monsoon had been blowing a light breeze from the northeast for a considerable period. Several officers on board had previously witnessed this interesting spectacle in different places, as the Gulf of Aden, the Bay of Bengal, the Sea of Java, in hot latitudes, and during the months of January and February, but none of them had observed it when it was so bright, or had noticed it for so long a time.—*La Nature.*

The Health-Cure as a Remedy for Adversity.—The "Lancet" suggests that more account ought to be taken than is taken of the condition of health in estimating the causes of success or failure in life. The habit of failing is formed in some families, and seems to be transmitted by inheritance; the same is the case with constitutional peculiarities, and often with certain morbid conditions. It would be an interesting and profitable study to examine how far what is called ill luck or bad fortune is induced by such peculiarities. Accepting this view, "so far from its being strange that failure or success should 'run in families,' it would be inexplicable, and contrary to every natural law and precedent, if it did not do so. The force of character, strength of will, clearness of mental vision, and qualities of vigor, patience, and perseverance, which constitute the secrets of success in life, are the several properties of the physical organism, compounded as it is of body and mind." A new cure is suggested, then, the "health-cure," as a remedy for adversity, which would be first personal, then hereditary in its aim, aspects, and bearing. The subject is worthy the attention of medical men and social philosophers.

Carrying a French Meridian into Africa.—Colonel Perrier furnishes a description to "La Nature" of the manner in which the French system of triangulations and the meridian lines have been extended into Algeria under his direction. The idea of establishing a geodesic connection across the Mediterranean had been entertained for more than seventy years, but it was considered doubtful, on account of the great distance from each other of the points that would have to be used in the observations, whether a correct measurement was practicable. Preparations for making the observations were begun in 1873. Four points were chosen (Mulhacen and Tetica in Spain, 11,537 feet and 676 feet above the sea, Filhaoussen and McSahiba in Algeria, 3,760 feet and 1,876 feet above the sea), which formed a quadrilateral the angles of which were all visible from each other. It was necessary, from considerations of climate and locality, to make all the observations in the latter part of the summer and the early fall. Solar reflections were to be used in the day, and the electric light at night, as signals. The solar reflections were never seen at any of the distant points, and proved a complete failure. After about twenty days of effort, the electric light was made visible at all the points, and was used successfully from the 10th of September till the 1st of October, when the first series of observations was satisfactorily completed. The calculations showed that, notwithstanding the extraordinary distances apart of the points of observation (one hundred and seventy miles), the solutions were as exact as in cases involving only a few miles. In making the astronomical projections of the points, a system of rhythmic signals, or of stated alternate flashes and eclipses of the electric light, was employed from the 5th of October to the 16th of November. It was found that these signals were susceptible of great precision, but that the personal equation could not be disregarded in observing them. This equation operated in a double sense, as related to the observation of the stars and of the signals, in each observer, and had to be ascertained by a series of special experiments instituted in the case of each person at the observatories at Paris. Practically, it was a matter of indifference to the observers whether they directed their attention to the flashes or to the eclipses of the light, but they considered the observations of the eclipses likely to be more exact. The most convenient rhythm of signals was found to be one of about two seconds, allowing one second for the flash and one second for the eclipse. The constancy of the personal equation as it related to the luminous signals was remarked, and the error to be allowed for was estimated at less than one hundredth of a second.

Mr. Fleuss's New Diving-Process.—We noticed in the March number of the "Monthly" the invention by Mr. Fleuss of a process for breathing under water, which dispenses for the most part with the cumbrous apparatus that divers have hitherto had to employ. A fuller account of the new method has been published since, in the English papers, and those features of it which were then kept secret have been disclosed. The power of breathing depends on means which are provided within the helmet worn by the diver. These means are designed to furnish a continuous supply of oxygen, and to dispose of the carbonic acid which the breather exhales. No provision is made for the nitrogen which enters into the composition of ordinary air, for this merely serves as a diluent, and is not changed or diminished in quantity by breathing; hence the nitrogen which is naturally present in the diver's lungs and in his dress when he puts it on can be used over and over again, and is amply sufficient for its purpose. The oxygen is stored in the helmet in a compressed state, and the supply is regulated by a valve which is under the control of the diver. A solution of caustic soda, distributed through the pores of a mass of spongy India-rubber and confined in a close case, is provided for the disposition of the carbonic acid. A proper arrangement of tubing causes the whole of the exhaled air to pass through this case and its soda. A single charging with soda answers for a week of daily use of the apparatus. Mr. Fleuss exhibited his confidence in his apparatus by putting it on and going under water for the first time in his life, and remaining there for more than an hour.

NOTES.

Professor William K. Kedzie, formerly Professor of Chemistry and Physics in the Kansas State Agricultural College, and Professor of Chemistry in Oberlin College, died at Lansing, Michigan, April 14th, in the twenty-ninth year of his age. As Chemist of the Kansas State Board of Agriculture, he performed valuable analyses of the soils, minerals, and vegetable products of Kansas. He planned the laboratory of the Kansas Agricultural College, and was the principal originator of the Natural History Society of the Michigan Agricultural College. His chief published writings are a work on the geology of Kansas and a number of articles contributed to the Kansas Academy of Science.

Soundings of the Niagara River below the falls have been taken by a party of United States engineers. A line, cast out as near to the falls as they could be approached in a small boat and near to the shore, gave 83 feet. Farther down the stream the line told off 100 feet, and at the inclined railway 192 feet. The average depth of the swift drift, where the river suddenly becomes narrow with a velocity too great to be measured, was 153 feet. Immediately below the bridge, where the whirlpool rapids set in, the depth was computed to be 210 feet.

The death is announced of Dr. J. G. Mulder, Professor of Chemistry in the University of Utrecht, in his seventy-eighth year.

Professor Nicholas Zinin, the eminent Russian chemist, died early in the present year, in the sixty-eighth year of his age. He was fifteen years a professor in the University of Kazan, after which, from 1848 to 1874, he was Professor of Chemistry in the Imperial Academy of Medicine at St. Petersburg.

The Summer School of Zoölogy of the Johns Hopkins University is established on an island near the mouth of Chesapeake Bay, for a term of six weeks. The place abounds in living organisms in such variety that the student has an opportunity of studying representatives of nearly all the larger groups of animals, and is free from mosquitoes and extreme heat.

A second specimen of the archæopteryx is on deposit in the Geological Museum at Berlin, with the expectation that it will be purchased. It was bought from its former owner for five thousand dollars by Herr Siemens, of Berlin, to prevent its being brought to this country.

M. Chevreul, who is now in his ninety-fifth year, has begun his course in chemistry at the Paris Museum of Natural History, with as much apparent zest and energy as he exhibited fifty years ago, when he first entered upon the duties of his chair.

Gelose is the name of the most valuable constituent of the substance known in commerce as China moss. It has the property of absorbing and solidifying into a colorless and diaphanous jelly five hundred times its weight of water, and is capable of forming ten times as much jelly by weight as the best animal gelatine.

Professor David Thomas Ansted, author of several works on geology and its applications, died May 20th. He was born in London in 1814, was appointed Professor of Geology in King's College, Cambridge, in 1840, and afterward Lecturer on Geology at other institutions, Assistant Secretary to the Geological Society, and editor of its quarterly journal.

Pertinent to the discussion concerning the fertility of hybrids, it is stated that the fertility of the progeny of the hare and the rabbit has been established for several generations. The hybrids are known in France as léporides, and have been constituted by Haeckel into the species *Lepus Huxleyii*.

The death of Professor Wilhelm Schimper, the distinguished Alsatian botanist, is announced. He was best known through his works on the mosses, in which department he was one of the leading authorities. He was also author of an important treatise on vegetable paleontology, and of several works on Alsatian botany and geology.

The death of Dr. Rudolph H. C. C. Scheffer, director of the botanical gardens at Buitenzorg, Java, which took place March 9th, causes a loss which will be felt by a large circle of botanists throughout the world. He had been director of the gardens for twelve years, and was in communication with every home and colonial institution.

JOSEPH LEIDY.

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THE SCIENCE OF COMPARATIVE JURISPRUDENCE.

By WILLIAM M. IVINS.

AN unbeliever in the possibilities of an exact historical science, Mr. Goldwin Smith, has said that history is like a child's box of letters, out of which we may spell whatsoever we please. As illustrative of his meaning, he might have taken the works of any of the old jurists, say Domat or Blackstone, for instance, and shown that that which they called history was too apt to be nothing more than a succession of ingenious but not always happy guesses. Writing upon the history of law, they used only such facts as squared with their preconceived philosophy of law—which philosophy, in its turn, was only another and slightly modified form of their dogmatic theology, from which it was a series of deductions. We owe the old legists, from the time of Gaius to that of Blackstone, a vast debt which we can never pay; but it is for the body of substantive law they have left us, not for their *bizarre* and unscientific speculations as to the origin and philosophy of law.

In his chapter on Rousseau's "Theory of the Social Compact," Mr. John Morley says: "Signal novelties in thought are as limited as signal inventions in architectural construction. It is only one of the great changes in method that can remove the limits of the old combinations, by bringing new material and fundamentally altering the point of view." The truth of this remark is nowhere better shown than in the very matter of which we have been speaking. If we may claim to know more than our forefathers about the actual historical development of law, it is only because we have become possessed of a new historical method which has already wrought signal, if not fundamental, alterations in our point of view so far as regards the origin and early history of institutions. I of course refer to the comparative method, which Professor Freeman, one of its greatest expositors, says marks "a stage in the progress of the human mind at least as great as the revival of Greek and Latin learning." This method had already led to wonderful achievements in the fields of language and religion, when Sir Henry Sumner Maine made the first noteworthy application of it to legal history in his now famous "Ancient Law." The earliest comparative study of European and Indian institutions was in the department of philology, and served to prove to demonstration that Sanskrit, Greek, Latin, and the Teutonic languages belonged to one common stock, and that the forefathers of Vergil and Sophocles, of the authors of the "Vedas" and the "Nibelungenlied" were related by community of race. This demonstration was soon followed by a great mass of confirmatory proofs from the fields of mythology and religion, and all of this earlier work was absolutely requisite before anything like a successful essay could be made in the field of comparative jurisprudence—so true is it, in the words of Mr. Symonds, that "language and mythology form the vestibules and outer courts to Homer, Phidias, and Lycurgus." The final preparation for a complete and thorough study of comparative jurisprudence was made possible when scholars like Mr. Tylor, Mr. Spencer, and Sir John Lubbock, went a step beyond the facts furnished by Indo-European peoples, and showed that prehistoric man was, to use the words of Mr. Bagehot, "substantially a savage, like present savages, in morals, intellectual attainments, and in religion," and that the prehistoric Aryan was no exception to this rule.

And now, before we define the scope and purpose of comparative jurisprudence—and there has been some doubt as to the propriety of using this term in the sense in which I shall use it—let us determine exactly what is meant by the comparative method. For illustrations and definitions, I might refer to Müller, Pictet, Freeman, and others who have done so much for comparative science, but I turn by preference to Professor Flint, because he has, in a single short paragraph, most happily described the new method, particularly as applied to legal history. "Social phenomena," says he, "such as laws, can not be explained by merely physical phenomena of natural philosophy and chemistry. The most distinct characteristics which they possess lie in their capacities for continuous evolution and development; and it is only by the study of their evolution, by the comparison of their consecutive states, and of each state with the coexisting general condition of society, that we can rationally hope to reach an adequate knowledge of their laws." This method, then, requires not only the study of English, ancient and modern Roman, Greek, and Hindoo law, but the study of the history of each; and not this alone, but the comparison of each with all of the others in such manner as accurately to learn their relations to each other, and to be able to mark off with something of precision those laws and political institutions which originally they all possessed in common, and which might fairly be denominated Aryan law. This method implies the study of law upon both its statical and its progressive sides, and discloses the processes by which it has been developed. The disclosure of the motives and processes of legal development I regard as unquestionably the most valuable of the fruits of comparative jurisprudence, for just behind them lies that subtile *lex legum* which has eluded the grasp of so many imaginative system-builders, but which is eventually destined to be as familiar learning to the scientific jurist as Grimm's law is to the modern philologer.

It will be readily seen, from this description of the comparative method, as particularly applied to the study of legal history and philosophy, that by the term comparative jurisprudence I mean something more than is usually meant by it when used by lawyers and legislators. These latter use the term as meaning a comparison of the legal systems of distinct and highly developed societies, to the end of the facilitation of legislation and the practical improvement of the law—which I should call comparative legislation. It must be admitted that what is here spoken of as comparative jurisprudence covers an area much wider than the field of law, but it does not therefore follow, as Sir Henry Maine is inclined to believe, that it should be called by some other name. Its field is unquestionably much larger than the field of positive law—which law is, in the words of Mr. Amos, "the enforceable general commands of a state," in the words of Mr. Austin, "law set by political superiors to political inferiors"; but it is not larger than the field of law as it was in archaic society. We may admit the claim that the existence of an organized political power, a state, is a condition precedent to the existence of law as understood in a political society like our own, yet there was law before there was political society, and, although it lacked many elements of the modern idea of law, it nevertheless was the original point of departure, and to it we must look for the historical roots of the positive law of to-day. If comparative jurisprudence deals with religions, ceremonials, customs, and politics, it is because it reaches back to a time when these and law were but slightly differentiated, when law had no peculiar accent of its own apart from that of the other institutional manifestations of social life. It can no longer be doubted that the law of evolution holds good, not only of organic processes, but of all super-organic processes as well—of the development of language, art, law, religion, and political institutions, and that in the beginning they were homogeneous and incoherent. So jurisprudence is compelled to regard something more than law simply, if it is to comprehend law. It has for its subject-matter the study of the relation of the fact law to all of the other facts of society, and so it goes back of positive law and seeks its springs and motives in systems like the early Roman and the Hindoo, where rites, liturgies, prayers, moral ordinances, and what we know distinctively as civil laws, appear to be mingled in mere senseless confusion. If the sphere of comparative jurisprudence is thus rendered larger than that of any of the other comparative sciences, it is only because law is the one social fact in which all others eventually lose themselves, and those others have to be known before law can be known. So jurisprudence requires a knowledge not only, as Ahrens reminds us, of "the group of conditions necessary for the physical and spiritual development of man so far as these conditions are dependent on human will," but of physical and spiritual conditions which predetermine law, and to which man has been no voluntary party.

In seeking the causes of ultimate social phenomena, we must always look to the history of the human mind, and its conditions antecedent to those phenomena. The most archaic—and I mean archaic in point of structure rather than in point of time—as well as the most modern social facts grow out of contemporaneous habits of thought. If the institutions of the earlier time or of the less civilized people differ materially from those of our civilized states, it is mainly because of difference in conditions and methods of thought. The introduction of the history of manners and institutions into general history accomplished a great revolution in methods of historical inquiry, for it laid open the hidden springs of national strength or weakness. It was Montesquieu's good fortune to be the first to successfully demonstrate this, but later on Jouffroy saw farther back along the line of cause and effect and clearly pointed out, what Mr. Herbert Spencer has since demonstrated, namely, that the chief agent in social evolution is belief.

It is not enough, then, for the student of comparative jurisprudence to know that archaic society presents startlingly vivid contrasts to the society of our day; to know that that political society which generations of inquirers have regarded as primordial is of recent growth; that time was when there was no state, no contractual, testamentary, or proprietary right in the individual—when the whole law, as yet customary, was summed up in status and kinship. If we are to account for these things, we must account for the state of society in which they existed; and, although such inquiry is not strictly or in any sense exclusively juridical, it is nevertheless prerequisite to a thorough and trustworthy comparative jurisprudence.

In proof of the last proposition, let us trace some of the steps that have been taken in the endeavor to find the ultimate reason of ancient law. Maine first followed back laws as far as the patriarchal family, which he justly calls "the type of archaic society in all the modifications which it is capable of assuming." But he makes no endeavor to account for the family, except by reference to the power of the father. He sets it down as a primordial and inexplicable social fact. He admits that he can not regard a disinclination to accept it as such as altogether unnatural, and yet he avows that he finds nothing in the superficial passions, habits, or tendencies of thought which at all sufficiently accounts for it. He recognized the value of a knowledge of the organizing cause of the family in antiquity, but gave up the search for it as hopeless. Others, more hopeful, have succeeded where he failed, until it has now been reduced to certainty that the constituent bond of the family was neither the *patria potestas*, nor simple community of blood, nor natural love and affection, and that neither of these things suffices to explain its existence, but that it finds its ultimate reason in religious principle and practice. In his treatise on "Hindu Law," Mr. John D. Mayne shows that ancestor-worship is the actual governing motive of native Indian jurisprudence to this day—ancestor-worship, the same principle which Coulanges so skillfully proved to be anterior to all Aryan social institutions, and which Spencer has found to be universal among all primitive peoples and the radical principle of all known religions. Coulanges erred in making the worship of the dead a finality, just as Maine erred—an error which I believe he has partially recognized—in believing the resources of his science insufficient to penetrate behind the *patria potestas*. The reason of ancestor-worship is discovered in the physical condition of primitive man, in his earliest methods of thought, his ideas of life and death, of life hereafter, and of the divine principle. Just as the student of the history of Roman law is forced to never lose sight of the patriarchal family—the nidus of those rudimentary ideas which are to the jurist what the primary crusts of the earth are to the geologist—so the student of the Aryan household must not only ever remember that its source is in the sentiment of religion, and that "the one unfailing centripetal force of archaic society" was community of worship, but he must go further, and place himself in a position to fully realize ancient habits of thought at the time when ancestor-worship was the dominant form of belief. To try to account for that belief by reasoning after our own approved methods—methods which at first seem to us to be the natural and only possible ones—is to grope hopelessly in the dark. We must make an effort to reconstruct primitive man on his intellectual side, as the paleontologist does on his anatomical side, and then to think as he thought. Here we leave our special department of laws and customs, and take up the study of general culture history; and, if in going back we lose distinctness and coherency, we shall find nevertheless the thing which shaped the thought at its birth, and that is the essential matter.

The only scholar who has as yet made any systematic and noteworthy effort to discover the causes of the primitive universality of ancestor-worship is Mr. Spencer, and his views are most worthy of attention, however liable they may be to future modification. He contends that ancestor-worship may be explained by having recourse to the ideas concerning sleep and dreams entertained by the earliest men, while they are still incapable of generalization and without any correct idea of causation and law, "lacking the very implements of developed thought." These ideas, he claims, account for primitive doctrines of immortality, which latter beget the worship of ancestors. Whether or not this theory of Spencer's, or Coulange's theory that early ideas of generation and creation afford the clew to the mystery, satisfactorily accounts for this primitive practice, the fact nevertheless remains, that the deification of the dead is the oldest religion known to men, which religion is the efficient cause of ancient social organization, the essential principle of archaic institutions, archaic morals, and archaic laws.

As to what those institutions and laws were, a simple discussion of the scope of comparative jurisprudence does not afford opportunity for inquiry. That they were utterly different from those of our own day may, however, be said. It seems to us, regarding law by the light of reason alone, that it must be somewhat more than immemorial usage, that it should acknowledge the principle of amendment and growth, and that it is something separate and distinct from religion; and yet ancient societies had an entirely different notion of it, regarding it as the revelation of some deity, hallowed by custom, and absolutely immutable in its principles, being nothing less than "religion applied to the relations of men among themselves." And so it would seem, from the reason of the thing, that there must always have been a law of contract as known to us, yet society had become far advanced in civilization before any such law was recognized and formulated. It would seem that the individual must always have held property in his own right, must always have been at liberty to dispose of it by some method of alienation during his life, and prescribed by will or testament some disposition of it after his death; and yet individual property and rights of alienation and testamentary bequest are, so to speak, new-fangled notions. In the same way we have come to regard local contiguity as the only possible basis of common political action; nevertheless, it is but yesterday that our Western world outgrew the assumption that community of worship or of blood was the sole natural ground of community in political organization. In like manner, we have been taught to believe that the individual is the necessary unit of society, and yet in all archaic societies the family is the only conceivable unit. And so the theory of relationship recognized by our law is apparently the only one which right reason can suggest; yet that theory would have appeared strange and unnatural to an ancient Brahman, or a Roman judge at the time of the Twelve Tables. Thus, "in its leading characteristics," to quote Mr. Hearn, "political, legal, religious, economic, archaic society presents a complete contrast to that in which we live. There was in it no central government, and consequently there were no political organs. There was no law to make, there was none to be executed. There were neither parliaments, nor courts of justice, nor executive officers. There was no national Church. The great bulk of property, not only as to its tenure, but as to its enjoyment, was in the hands—not of individuals, but of corporate households. There were few contracts, and no wills. Men lived according to their customs. They received their property from their fathers, and transmitted it to their heirs. They were protected, or, if need, were avenged, by the help of their kinsmen. There was, in short, neither individual nor state. The clan, or some association founded upon the model of the clan, and its subdivisions, filled the whole of our forefathers' social life."

Now, how far a knowledge of these things, as taught by comparative jurisprudence, must modify our notions of legal history, is self-apparent. The great mass of speculation in the department of social science has heretofore been uniformly wrong, simply because it never spontaneously entered the modern mind that society was possible without states, kings, parliaments, and positive laws. These elements of modern social life were combined and recombined in numberless ingenious ways in the endeavor to reconstruct the past, but it was never dreamed that they must be absolutely discarded. An organized state, political sovereignty, and sanctioned laws were regarded as essential prerequisites to social existence; and, until the last generation of thinkers, there was not one who contributed a word to the philosophy of history who did not regard the state as the only possible condition of human society. It is easily seen, consequently, why Locke and Hobbes, Rousseau and Montesquieu, and the rest, were hopelessly wrong in their views concerning the origin of the state and the laws. It needed a great change in method to disclose to us their fundamental error; and now that the comparative method of historical induction is established upon a *quasi*-scientific basis, we are in a fair way to rectify century-old misconceptions.

Not the least of the beneficial results which are destined to follow upon the growth of a science of comparative jurisprudence is this, that we shall be taught to realize, more fully than ever before, that all of the phenomena of society, politics, religion, ethics, economics, art, are presented simultaneously by society, and constitute a plexus of interacting causes and effects, independent and yet interpenetrating one another, each of which can only be understood by the light of all.

Two other great lessons this science will be the means of teaching to the world. The first is the exact nature of the relation of custom to law; the second the exact relation of custom and law to legislation. It is obvious that, as the state is a comparatively recent formation, there must have been, as in fact there was, a time when men's conduct was not ruled by anything corresponding to what we know as the law of the state; but it did not, therefore, go uncontrolled. The force which then assumed the place as a rule of conduct which law fills among modern peoples was custom. Now, custom is wholly unlike law as defined by the analytical jurists, in these respects, namely, because first it does not imply a command from any political superior, and because it is enforced by public opinion rather than by a sovereign political power. While it is thus essentially unlike positive law, it nevertheless "furnishes both the motive and the material for law," and eventually becomes law when the state comes into existence and supplements public opinion with an authoritative sanction. Keller's statement of this is not only so happy, but so perfectly accordant with the fact, as to demand remembrance. "Legal notions," says he, "commence by being instinctively observed in the relations of life, and act upon those relations as a natural force; exactly as is the case in regard to language and manners. But afterward organized human society draws them within the sphere of its conscience and of its freedom of action, and by its creative power gives them a positive form and a determined efficacity." Custom, then, differs from law mainly in the matter of form and sanction, not necessarily in its requirements. The two are, in fact, only earlier and later developments of the same social fact, depending for their evolution upon the play of human qualities in the necessary relations of society.

The second great practical lesson which will be taught by comparative jurisprudence is, as I have said, the knowledge of the true relations of custom and law to legislation. Law is the statical, legislation the dynamical side of the same fact. The lawyer studies what is, the legislator what ought to be. The jurist is he who studies what has been, what is, and what ought to be. The true jurists, the true legislators, will learn from comparative jurisprudence the *lex legum* of which I have spoken; will know the veneration due to those institutions and laws which are the surest exponents of national genius, while they obey implicitly the spirit of progress. Thus they will regard it as a duty to permit no legislation which is not in accord with the genius of the nation, or which would force the law to a hurried or abnormal growth.

And as comparative jurisprudence has borrowed from culture history, so will it pay back its debt to the science of social organization, and demonstrate the eternal absurdity of such schemes as those of Saint-Simon, Fourier, Proudhon, and Louis Blanc; schemes which are not only retrogressive but which contain within themselves a subtile poison hostile to the essential principles of all society. A profound comparative jurisprudence will give the death-blow to "those alchemists of thought," to use the words of Wolowski, "who imagine that society may be made to undergo a transformation between the rising and the setting of the sun."

The great movement of society has been a slow and painful progression from clan society, governed by the law of status, to political society, based upon the principle of individualism; from a society in which individual self-government was unknown, to one which first organized a single central governing power, and which has ever since been limiting that power in favor of the largest practicable individualism. The history of these changes is the history of social progress, of civilization; but it is unintelligible apart from comparative jurisprudence, which is not only the forerunner of a complete science of history, but of the true philosophy of law, which shall rise above all forms and customs, and discover to mankind the generative principle of the just and of the unjust, and make of positive law nothing less than organized justice and right. When that science has been achieved we shall, for the first time, see the real character of that actual law of nature which was undreamed of by Ulpian and Grotius, a law not disclosed to us at the beginnings of society, but only to be disclosed at its end; not while man's possibilities are unfathomed, but when he shall have grown to his noblest nature. Never may we rise to a knowledge of uniform law, uniform justice, until law and justice have manifested themselves to us in perfection, and that will be when their evolution has been completed, not before. The beginning is no nearer nature than the end, for all is nature. Whatever man has been, whatever may be, is due to a larger law, of which positive law is but a part. That law is the true law of Nature, and is knowable only by its manifestations, not by vain guessings as to its character. It can never be wholly known, for Nature discloses herself gradually, and her law will not be made manifest until the end has come.

STATE EDUCATION: A HELP OR HINDRANCE?

By the Hon. AUBERON HERBERT.

FOR ten years we have been busy organizing national education. A vigorous use of bricks and mortar is not generally accompanied by a careful examination of first principles,* but now that we have built our buildings and spent our millions of public money, and civilized our children in as speedy a fashion as that in which the great Frank Christianized his soldiers, we may perhaps find time to ask a question which is waiting to be discussed by every nation that is free enough to think, whether a state education is or is not favorable to progress?†

It may seem rash at first sight to attack an institution so newly created and so strong in the support which it receives. But there are some persons, at all events, whom one need not remind that no external grandeur and influence, no hosts of worshipers can turn wrong

* Has Mr. Leslie Stephen said somewhere, that it is easier to build churches than to think about what is to be taught inside of them?

† I ought to say that I have changed my opinions as regards the action of the state since 1870. I could not have made this change without the assistance of Mr. Herbert Spencer's writings.

principles into right principles, or prevent the discovery, by those who are determined to see the truth at any cost, that the principles are wrong. Sooner or later every institution has to answer the challenge; "Are you founded on justice? Are you for or against the liberty of men?" And to this challenge the answer must be simple and straightforward; it must not be in the nature of an outburst of indignation that such a question should be asked; or a mere plea of sentiment; or the putting forward of usefulness of another kind. These questions of justice and liberty stand first; they can not take second rank behind any other considerations, and if in our hurry we throw them on one side, unconsidered and unanswered, in time they will find their revenge in the imperfections and failure of our work.

National education is a measure carried out in the supposed interest of the workmen and the lower middle class, and it is they especially—the men on whose behalf the institution exists—whom I wish to persuade that the inherent evils of the system more than counterbalance the conveniences belonging to it.

I would first of all remind them of that principle which many of us have learned to accept, that no man or class accepts the position of receiving favors without learning, in the end, that these favors become disadvantages. The small wealthy class which once ruled this country helped themselves to favors of many kinds. It would be easy to show that all these favors, whether they were laws in protection of corn, or laws favoring the entail of estates, creating sinecures, or limiting political power to themselves, have become in the due course of time unpleasant and dangerous burdens tied round their own necks. Now, is state education of the nature of a political favor?

It is necessary, if discussion is in any way to help us, to speak the truth in the plainest fashion, and therefore I have no hesitation in affirming that it is so. Whenever one set of people pay for what they do not use themselves, but what is used by another set of people, their payment is and must be of the nature of a favor, and does and must create a sort of dependence. All those of us who like living surrounded with a slight mental fog, and are not over-anxious to see too clearly, may indignantly deny this; but if we honestly care to follow Dr. Johnson's advice, and clear our minds of cant, we shall perceive that the statement is true, and, if true, ought to be frankly acknowledged. The one thing to be got rid of at any cost is cant, whether it be employed on behalf of the many or the few.

Now, what are the results of this particular favor? The most striking result is that the wealthier class think that it is their right and their duty to direct the education of the people. They deserve no blame. As long as they pay by rate and tax for a part of this education, they undoubtedly possess a corresponding right of direction. But having the right they use it; and, in consequence, the workman of to-day finds that he does not count for much in the education of his children. The richer classes, the disputing churches, the political organizers, are too powerful for him. If he wishes to realize the fact for himself, let him read over the names of those who make up the school boards of this country. Let him first count the ministers of all denominations, then of the merchants, manufacturers, and squires. There is something abnormal here. These ministers and gentlemen do not place the workmen on committees to manage the education of their children. How, then, comes it about that they are directing the education of the workmen's children? The answer is plain. The workman is selling his birthright for the mess of pottage. Because he accepts the rate and tax paid by others, he must accept the intrusion of these others into his own home affairs—the management and education of his children. Remember, I am not urging, as some do, the workmen to organize themselves into a separate class, and return only their own representatives as members of school boards; such action would not mend the unprofitable bargain. To take away money from other classes, and not to concede to them any direction in the spending of it, would be simply unjust—would be an unscrupulous use of voting power. No, the remedy must be looked for in another direction. It lies in the one real form of independence—the renunciation of all obligations. The course that will restore to the workmen a father's duties and responsibilities, between which and themselves the state has now stepped, is for them to reject all forced contributions from others, and to do their own work through their own voluntary combinations. Until that is done no workman has more, or has a claim to have more, than half rights over his own children. He is stripped of one half of the thought, care, anxiety, affection, responsibility, and need of judgment which belong to other parents.

I used the expression, the forced contributions of the rich. There are some persons who hold that the more money you can extract by legislation from the richer classes for the benefit of the poorer classes the better are your arrangements. I entirely dissent from such a view. It is fatal to any clear perception of justice. Justice requires that you should not place the burdens of one man on the shoulders of another man, even though he is better able to bear them. In plainer words, that you should not make one set of men pay for what is used by another set of men. If this law be once disregarded, it simply reduces politics to a universal scramble, in which the most selfish will have the most success. It turns might into right, and proclaims that each man may rightfully possess whatever he can vote into his pocket. Whoever is intent on justice must be as just to the rich man as to the poor man; and, because so-called national education is not for the children of the rich man, it is simply not just to take by compulsion one penny from him. No columns of sophistry can alter this fact. And yet, when once the obligation disappears, and the grace of free-giving is restored, it is a channel in which the money of the richer classes may most worthily flow. Whatever the faults are of our richer classes, there is no lack among them of generous giving. Take any newspaper, and you will find that, although by unwise legislation we are closing many of the great channels existing for their gifts, yet the quality persists. The endowment of colleges at one period, the endowment of grammar-schools at another period, gifts to religious institutions, and the support given to that narrow, partial, vexatious, and official-minded system of education which prevailed up to 1870, are all evidence of what the richer people are ready to do as long as you do not withhold the opportunities. It may, however, be said, "Do not rich gifts bring obligations, and with them their mischievous consequences?" It is plain that the most healthy state of education will exist when the workmen, dividing themselves into natural groups according to their own tastes and feelings, organize the education of their children without help, or need of help, from outside. But between obligatory and voluntary contributions there is the widest distinction. There is but slight moral hurt to the giver or receiver in the voluntary gift, provided only that the spirit on both sides be one of friendly eqyality. It is the forced contribution, bringing neither grace to the giver nor to the receiver, which has the evil savor about it, and brings the evil consequence. The contribution taken forcibly from the rich is justified on the ground that the thing to be provided is a necessity for which the poorer man can not pay. Thus the workman is placed in the odious position of putting forward the pauper's plea, and two statements equally deficient in truth are made for him: one, that book-education is a necessity of life—a statement which for those who look for an exact meaning in words that are used is simplu not true; and the other, that our people can not provide it for themselves if left to do so in their own fashion.*

I wish to push still further the question of how much real power the workman possesses over the education of his children. I maintain that, setting aside the interference of ministers, merchants, manufacturers, doctors, lawyers, and squires in his affairs, he has only the shadow and semblance of power, and that he never will possess anything more substantial under a political system. Let us see for what purposes political organization can be usefully applied. It is well adapted to those occasions when some definite reply has to be made to a simple question. Shall there be peace or war? shall political power be extended to a certain class? shall certain punishments follow certain crimes? shall the form of government be republican or monarchical? shall taxes be levied by direct or indirect taxation? These are all questions which can be fairly answered by Yes or No, and on which every man enrolled in a party can fairly express his opinion if he has once

* At the same time a thorough and radical readjustment of our educational endowments is required in the interest of the workmen, who, though in most cases having the first claim, derive little or no advantage from them.

decided to affirm or deny. But, whenever you call upon part of the nation to administer some great institution, the case becomes wholly different. Here all the various and personal views of men can not be represented by a simple Yes or No. A mixed mass of men, like a nation, can only administer by suppressing differences and disregarding convictions. Take some simple instance. Suppose a town of fifty thousand electors should elect a representative to assist in administering some large and complicated institution. Let us observe what happens. It is only possible to represent these fifty thousand people, who will be of many different mental kinds and conditions, by some principle which readily commands their assent. It will probably be some principle which, from its connection with other matters, is already familiar to their mind—made familiar by preceding controversies. For example, the electors may be well represented on such questions as "Shall the institution be open or closed on Sundays? shall it be open to women? shall the people be obliged to support it by rate? and, when rate-supported, to make use of it?" But it will at once be seen that these are principles which do not specially apply to any one institution but to many institutions. They are principles of common political application—they are, in fact, external to the institution itself, and distinct from its own special principles and methods. The effect, then, will be that the representative will be chosen on principles that are already familiar to the minds of the electors, and not on principles that peculiarly and specially affect the institution in question. Existing controversies will influence the minds of the electors, and the constituency will be divided according to the lines of existing party divisions. Both school boards and municipal government yield an example that popular elections must be fought out on simple and familiar questions. The existing political grooves are cut too deeply to allow of any escape from them.

"But," it may be replied, "as intelligence increases, and certain great political questions which are always protruding themselves are definitely settled, the electorate may become capable of conducting their contests simply with regard to the principles which really belong to the matter itself." Another difficulty arises here. Without discussing the possible settlement of these ever-recurring political questions, it ought to be remembered that, in the case of increased intelligence, we should have an increase in the number of different views affecting the principles and methods of the institution in question; and, as we should still have only one representative to represent us, it would be less possible for him than before to represent our individual convictions. If he represent A he can not represent B, nor C, nor any of those that come after C; that is to say, if A, B, C, and the others are all thinking units, and therefore do not accept submissively whatever is offered to them. He can only represent one section, and must leave other sections unrepresented. But as these individual differences are both the accompaniment and sign of increasing intelligence, this unhappy result follows, that the more intelligent a nation becomes, the greater pain it must suffer from a system which forces its various parts to think and act alike when they would naturally be thinking and acting differently.

"But if this is so, then there is no such thing possible as representation. If one person can not represent many persons, then administration of all kinds fails equally in fulfilling a common purpose. All united effort, therefore, becomes impossible."

No doubt effective personal representation is under any circumstances a matter of difficulty; but political organization admits only of the most imperfect form of it, voluntary organization of the most perfect. Under political organization you mix everybody together, like and unlike, and compel them to speak and act through the same representative; under voluntary organization like attracts like, and those who share the same views form groups and act together, leaving any dissident free to transfer his action and energy elsewhere. The consequence is that under voluntary systems there is continual progress, the constant development of new views, and the action necessary for their practical application; under political systems, immobility on the part of the administrators, discontented helplessness on the part of those for whom they administer.

"But still there remain certain things which, however much you may desire to respect personal differences, the state must administer; such, for example, as civil and criminal law, or the defense of the country."

The reason why the nation should administer a system of law, or should provide for external defense, and yet abstain from interference in religion and education, will not be recognized until men study with more care the foundations on which the principle of liberty rests. Many persons talk as if the mere fact of men acting together as a nation gave them unlimited rights over each other; and that they might concede as much or as little liberty as they liked one to the other. The instinct of worship is still so strong upon us that, having nearly worn out our capacity for treating kings and such kind of persons as sacred, we are ready to invest a majority of our own selves with the same kind of reverence. Without perceiving how absurd is the contradiction in which we are involved, we are ready to assign to a mass of human beings unlimited rights, while we acknowledge none for the individuals of whom the mass is made up. We owe to Mr. Herbert Spencer—the truth of whose writings the world will one day be more prepared to acknowledge, after it has traveled a certain number of times from Bismarckism to communism, and back from communism to Bismarckism—the one complete and defensible view as to the relations of the state and the individual. He holds that the great condition regulating human intercourse is the widest possible liberty for all. Happiness is the aim that we must suppose attached to human existence ; and therefore each man must be free—within those limits which the like freedom of others imposes on him—to judge for himself in what consists his happiness. As soon as this view is once clearly seen, we then see what the state has to do and from what it has to abstain. It has to make such arrangements as are necessary to insure the enjoyment of this liberty by all, and to restrain aggressions upon it. Wherever it undertakes duties outside this special trust belonging to it, it is simply exaggerating the rights of some who make up the nation and diminishing the rights of others. Being itself the creature of liberty, that is to say, called into existence for the purposes of liberty, it becomes organized against its own end whenever it deprives men of the rights of free judgment and free action for the sake of other objects, however useful or desirable they may be.

It is on account of our continued failure to recognize this law of liberty that we still live, like the old border chieftains, in a state of mutual suspicion and terror. Far the larger amount of intolerance that exists in the world is the result of our own political arrangements, by which we compel ourselves to struggle, man against man, like beasts of different kinds bound together by a cord, each trying to destroy the other out of a sense of self-preservation. It is evident that the most fair-minded man must become intolerant if you place him in a position where he has only the unpleasant choice either to eat or be eaten, either to submit to his neighbor's views or force his own views upon his neighbor. Cut the cord, give us full freedom for differing among ourselves, and it at once becomes possible for a man to hold by his own convictions, and yet be completely tolerant of what his neighbor says and does.

I come now to another great evil belonging to our system. The effort to provide for the education of children is a great moral and mental stimulus. It is the great natural opportunity of forethought and self-denial ; it is the one daily lesson of unselfishness which men will learn when they will pay heed to none other. There is no factor that has played so large a part in the civilization of men as the slow formation in parents of those qualities which lead them to provide for their children. In this early care and forethought are probably to be found the roots of those things which we value so highly—affection, sympathy, and restraint of the graspings of self for the good of others. We may be uncertain about many of the agents that have helped to civilize men, but here we can hardly doubt. What, then, is likely to be the effect when, heedless of the slow and painful influences under which character is formed, you intrude a huge, all-powerful something you call the state between parents and children, and allow it to say to the former : "You need trouble yourself no more about the education of your children. There is no longer any occasion for that patience and unselfishness which you were beginning to acquire, and under the influence of which you were learning to forego the advantage of their labor, that they might get the advantage of education. We will give you henceforth free dispensation from all such painful efforts. You shall at once be made virtuous and unselfish by a special clause in our act. You shall be placed under legal obligations, under penalty and fine, to have all the proper feelings of a parent. Why toil by the slow, irksome process of voluntary efforts and your own growing sense of right to do your duty, when we can do it so easily for you in five minutes? We will provide all for you—masters, standards, examinations, subjects, and hours. You need have no strong convictions, and need make no efforts of your own, as you did when you organized your chapels, your benefit societies, your trade societies, or your coöperative institutions. We are the brain that thinks; you are but the bone and muscles that are moved. Should you desire some occupation, we will throw you an old bare bone or two of theological dispute. You may settle for yourselves which dogmas of the religious bodies you prefer; and while you are fighting over these things our department shall see to the rest for you. Lastly, we will make no distinctions between you all. The good and the bad parent shall stand on the same footing, and our statutes shall assume with perfect impartiality that every parent intends to defraud his child, and can only be supplied with a conscience at the police-court." This cynical assumption of the weakness and selfishness of parents, this disbelief in the power of better motives, this faith in the inspector and policeman, can have but one result. Treat the people as unworthy of trust, and they will justify your expectation. Tell them that you do not expect them to possess a sense of responsibility to think or act for themselves, withhold from them the most natural and the most important opportunities for such things, and in due time they will passively accept the mental and moral condition you have made for them. I repeat that the great natural duties are the great natural opportunities of improvement for all of us. We can see every day how the wealthy man, who strips himself entirely of the care of his children, and leaves them wholly in the hands of tutors, governesses, and schoolmasters, how little his life is influenced by them, how little he ends by learning from them. Whereas, to the man whose thoughts are much occupied with what is best for them, who is busied with the delicate problems which they are ever suggesting to him, they are a constant means of both moral and mental change. I repeat that no man's character, be he rich or poor, can afford the intrusion of a great power like the state between himself and his thoughts for his children. Observe the corresponding effect in another of our great state institutions. The effect of the poor law—which undertakes the care in the last resort of the old and helpless—has been to break down to a great extent the family feelings and affections of our people. It is simply and solely on account of this great machine that our people, naturally so generous, recognize much less the duty of providing for an old parent than is the case either in France or Germany. With us, each man unconsciously reasons, "Why should I do that which the state will do for me?" All such institutions possess a philanthropical outside, but inwardly they are full of moral helplessness and selfishness.

These, then, are the first charges that I bring against state education: that the forced payments taken from other classes place the workman under an obligation; that, in consequence, the upper and middle classes interfere in the education of his children; that under a political system there is no place for his personal views, but that practically the only course of action left open to him is to join one of the two parties who are already organized in opposition to each other, and record a vote in favor of one of them once in three years. I do not mean to make the extreme statement that it is impossible to persuade either one party or both parties to adopt some educational reform, but I mean to say that one body acting for a whole country or a whole town can only pursue one method, and therefore must act to the exclusion of all views which are not in accordance with that one method; and that bodies which are organized for fighting purposes, and whose first great object is to defeat other great bodies nearly as powerful as themselves, are bound by the law of their own condition not to be easily moved by considerations which do not increase their fighting efficiency.

I have just touched upon the evils of uniformity in education; but there is more to say on the matter. At present we have one system of education applied to the whole of England. The local character of school boards deceives us, and makes us believe that some variety and freedom of action exist. In reality they have only the power to apply an established system. They must use the same class of teachers; they must submit to the same inspectors; the children must be prepared for the same examinations, and pass in the same standards. There are some slight differences, but they are few and of little value. Now, if any one wishes to realize the full mischief which this uniformity works, let him think of what would be the result of a uniform method being established everywhere—in religion, art, science, or any trade or profession. Let him remember that canon of Mr. Herbert Spencer, so pregnant with meaning, that progress is difference. Therefore, if you desire progress, you must not make it difficult for men to think and act differently; you must not dull their senses with routine, or stamp their imagination with the official pattern of some great department. If you desire progress, you must remove all obstacles that impede for each man the exercise of his reasoning and imaginative faculties in his own way; and you must do nothing to lessen the rewards which he expects in return for his exertions. And in what does this reward consist? Often in the simple triumph of the truth of some opinion. It is marvelous how much toil men will undergo for the sake of their ideas; how cheerfully they will devote life, strength, and enjoyment to the work of convincing others of the existence of some fact, or the truth of some view. But, if such forces are to be placed at the service of society, it must be on the condition that society should not throw artificial and almost insuperable obstacles in the way of those reformers who search for better methods. If, for example, a man holding new views about education can at once address himself to those in sympathy with him, can at once collect funds and proceed to try his experiment, he sees his goal in front of him, and labors in the expectation of obtaining some practical result to his labor. But if some great official system blocks the way; if he has to overcome the stolid resistance of a department; to persuade a political party, which has no sympathy with views holding out no promise of political advantage; to satisfy inspectors, whose eyes are trained to see perfection of only one kind, and who may summarily condemn his school as "inefficient," and therefore disallowed by law; if in the mean time he is obliged by rates and taxes to support a system to which he is opposed—it becomes unlikely that his energy and confidence in his own views will be sufficient to inspire a successful resistance to such obstacles. It may be said that a great official department, if quickened by an active public opinion, will be ready to take up the ideas urged on it from outside. But there are reasons why this should not be so. When a state department becomes charged with some great undertaking, there accumulates so much technical knowledge round its proceedings that, without much labor and favorable opportunities, it becomes exceedingly difficult to criticise successfully its action. It is a serious study in itself to follow the minutes and the history of a great department, either like the local board or the education department. And, if a discussion should arise, the same reason makes it difficult for the public to form a judgment in the matter. A great office which is attacked envelops itself, like a cuttle-fish, in a cloud of technical statements which successfully confuses the public, until its attention is drawn off in some other direction. It is for this reason, I think, that state departments escape so easily from all control, and that such astounding cases of recklessness and mismanagement come periodically to light, making a crash which startles everybody for the moment. The history of our state departments is like that of some Continental governments, unintelligent endurance through long periods on the part of the people, tempered by spasmodic outbursts of indignation and ineffectual reorganization of the institutions themselves. It must also be remembered that the manner in which new ideas produce the most favorable results is not by a system under which many persons are engaged in suggesting and inventing, and one person only in the work of practical application. Clearly the most progressive method is that whoever perceives new facts should possess free opportunities to apply and experiment upon them.

Add one more consideration. A great department must be by the law of its own condition unfavorable to new ideas. To make a change it must make a revolution. Our education department, for example, can not issue an edict which applies to certain school boards and not to others. It knows and can know of no exceptions. Our bastard system of half-central half-local government is contrived with great ingenuity to render all such experiments impossible. If the center were completely autocratic (which Heaven forbid!), it could try such experiments as it chose; if the localities were independent, each could act for itself. At present our arrangements permit of only intolerable uniformity. Follow still further the awkward attempts of a department at improvement. Influenced by a long-continued public pressure, or moved by some new mind that has taken direction of it, it determines to introduce a change, and it issues in consequence a wholesale edict to its thousands of subordinates. But the conditions required for the successful application of a new idea are, that it should be only tentatively applied; that it should be applied by those persons who have some mental or moral affinity with it, who in applying it work intelligently and with the grain, not mechanically and against the grain. No wonder, therefore, that departments are so shy of new ideas, and by a sort of instinct become aware of their own unfitness to deal with them. If any one wishes to realize why officialism is what it is, let him imagine himself at the center of some great department which directs an operation in every part of the country. Whoever he was, he must become possessed with the idea of perfect regularity and uniformity. His waking and sleeping thought would be the desire that each wheel should perform in its own place exactly the same rotation in the same time. His life would simply become intolerable to him if any of his thousands of wheels began to show signs of consciousness, and to make independent movements of their own.

But suppose that a man of fresh mind and personal energy were to be placed at the head of our education department who perceived the mischievous effect of uniformity, could not this official tendency be counteracted? It might for a short space of time, just as the muscles of a strong man can for some hours defeat the pull of gravitation, but gravitation wins in the end. Such changes would be only spasmodic; they would not be the natural outcome of the system, and therefore could not last. Moreover, for those who understand the value of liberty and of responsibility, it is needless to point out how utterly false the system must be which makes the nation depend upon the intelligence of a minister, and not upon the free movement of the different minds within itself.

I come now to another great evil which accompanies an official system. In granting public money for education you must either give it on the judgment of certain public officers, which exposes you to different standards of distribution and to personal caprice, or you must give it according to some such system of results as exists at present with us. Payment by results has the merit, as a system, of being simple, easy to administer, and fairly equal; but it necessarily restricts and vulgarizes our conceptions of education. It reduces everybody concerned, managers, teachers, pupils, to the one aim and object of satisfying certain regulations made for them, of considering success in passing standards and success in education as the same thing. It is one long, unbroken grind.* From boyhood to manhood the teacher himself is undergoing examinations; for the rest of his life he is reproducing on others what he himself has gone through. It is needless to say that the higher aims of the teacher, methods of arousing the imagination and developing the reasoning powers, which only bear fruit slowly and can not be tested by a yearly examination of an inspector—whose fly will be waiting at the school-door during the few hours at the disposal of himself or his subordinate—new attempts to connect the meaning of what is being learned with life itself, and to create an interest in work for work's own sake instead of for the inspector's sake, above all, the personal influences of men who have chosen teaching as their vocation, because the real outcome of their nature is sympathy with the young, and have not been drilled into it through a series of examinations owing to some accident of early days, all these things must be laid aside as subordinate to the one great aim of driving large batches successfully through the standards and making large hauls of public money. In our ignorant and unreasoning belief in examinations we have not perceived how fatal the system is to all original talent and strong personality in the teacher. Whether it be a professor at a university or a master in a board school, this modern exaggeration of the use of examinations makes it impossible for him to treat his subjects of teaching from that point of view which is real and living to himself, or to follow his own methods of influencing his pupils. In all cases he must subdue his strongest tastes and feelings, and recast and remodel himself until he is a sufficiently humble copy of the inspector or examiner, upon whose verdict his success depends. Any plan better fitted to reduce managers, teachers, and pupils to one level of commonplace and stupidity could scarcely be found. The state rules a great copy-book, and the nation simply copies what it finds between the lines.

I can not escape a few words on the much-vexed religious question. Under our present system the Nonconformists are putting a grievous strain upon their own principles. Whoever fairly faces the question must admit that the same set of arguments which condemns a national religion also condemns a national system of education. It is hard to pronounce sentence on the one and absolve the other. Does a national Church compel some to support a system to which they are opposed?

* See an article bearing on this point by Mr. Fitch. I have not the reference by me at this moment.

So does a national system of education. Does the one exalt the principle of majorities over the individual conscience? So does the other. Does a national Church imply a distrust of the people, of their willingness to make sacrifices, of their capacity to manage their own affairs? So does a national system of education. Does the one chill and repress the higher meanings, and produce formalism? So does the other. But everywhere Nonconformists are being drawn into supporting the present school system, into obtaining popular influence by means of it, and, what is most inconsistent and undesirable, into using it as an instrument for spreading their own religious teaching. It is rapidly becoming their established Church, and it will have, we may safely predict, the same narrowing effect upon their mind, it will beget the same inability to perceive the injustice of a political advantage, which the national Church has had upon its supporters. Such a result is matter for much regret. First, because there is already but little steady adherence to principle in politics; and where a large body of influential men put themselves in a position which is inconsistent with the application of their own principles there is a sensible national deterioration. Secondly, if school boards are to be instruments of authoritatively teaching subjects of common dispute among us, such as the inspiration of the Bible and the performance of miracles, the struggle between the supporters of revealed religion and the different schools of free-thought must be embittered. It is the question of political advantage and disadvantage which fans these disputes into red heat. Should this be the case, much of the better side of the present religious teaching will be lost sight of by a large part of the nation under the irritation of the political injustice, and its influence lost at a moment when its influence is especially wanted in shaping the new beliefs.

It may be said that secular education will prevent such antagonism, and that every year brings us nearer to the establishment of it. But secular education, even if it be the most just arrangement of trying to meet the injustice which a state system necessarily brings with it, is, at best, a miserable expedient. It is as if everybody agreed by common contract to tie up his right hand in doing a special piece of work in which he was most interested. Far healthier would it be for each section in the nation, from the Catholic to the materialist, to regain perfect freedom, and to do his best to place before children the scheme of life as he himself sees and feels it. If the common argument, that such separate teaching will produce narrowness of mind and sectarian jealousy, is to be regarded, it should be carried a step further, and the children on Sundays should not be permitted to go to their own churches and chapels, but the state should provide a universal temple which ceremonies adapted for all. I confess, for my own part, that I prefer to see intensity of conviction, even if joined with some narrowness, to a state of moral and intellectual sleepiness, and children waiting to be fed with such scanty crumbs as fall from official tables.

It only wants an effort to shake off the thralldom of familiar ideas and to see with fresh eyes, and then the monstrous fact, that all England is placing itself under official restraints as regards that which it cares most about, would be enough to show us that there must be something radically wrong in a system which necessarily carries with it such a disqualification.

"But what are we to do?" is the impatient exclamation of many persons who feel both the pretensions and the poverty-stricken character of our present system. "Could education be supplied without official assistance?" My answer is that it could; that the combining and coöperative power of our people would provide for this great want, as it is providing for their religious and social wants; that money is waiting to flow from some of the richer people, if so plain and good an outlet were left open—money which is at present doing harm by creating scholarships and increasing the power of examinations—that good citizenship essentially consists in those who have learned to value some gift of civilization awakening the same sense in those who remain indifferent. "But why did not education spread quicker in the earlier part of the century?" No truly great thing grows like a mushroom. An intelligent value for education can only spread slowly like civilization itself. In our hurry to act we have not seen how much life and movement is sacrificed to make place for an official system. Those who administer such systems wish to get the flower ready-made without any process of growth. They do not recognize in the early and imperfect efforts the first stage of growth from which the better form will spring, but they wish to start at once with that which will satisfy their own rather prudish eyes. A certain uniform standard is fixed, and all that falls short of it is declared infamous. Of course, it is always possible to smear education, religion, or anything else, over a country, as you might smear paint, by departments or boards, and in five years be able to glorify your great work and to cram your speeches with statistics of what you have done. Every autocrat with ideas in his head has done the same thing, but he has also left it to his successors to moralize over the results of his work. Education when still left to itself did spread, perhaps too rapidly, in the beginning of the century. Presented to the English people by Lancaster, it was received like a gospel of good news; and, although many of the early schools were of exceedingly humble and imperfect form, yet the want was beginning to be felt, and the supply was following. Then came the unwise, if well-intentioned, assistance of Government. As usual, the political philanthropists could not endure to see a movement taking its own direction and shaping itself. As soon as the idea of Government responsibility had taken root, the evil was done. It is a mistake to suppose that Government effort and individual effort can live side by side. The habits of mind which belong to each are so different that one must destroy the other. In the course of time there fell alike over everybody concerned the shadow of coming changes, and work which would have been done resolutely and manfully, if no idea of Government interference had existed, remained undone, because the constant tendency of Government to enlarge its operations was felt everywhere. The history of our race shows us that men will not do things for themselves or for others if they once believe that such things can come without exertion on their own part. There is not sufficient motive. As long as the hope endures that the shoulders of some second person are available, who will offer his own shoulders for the burden? It must also be remembered that, unless men are left to their own resources, they do not know what is or what is not possible for them. If Government half a century ago had provided us all with dinners and breakfasts, it would be the practice of our orators to-day to assume the impossibility of our providing for ourselves.

And now, leaving much unsaid, I must ask what practical steps should be taken by those workmen who suspect that state education is but a part of that coercive drill which one half the human race delights to inflict upon the other half. First of all, get rid of compulsion. It has been made the instrument of endless petty persecutions. It is fatal to the free growth of an intelligent love of education; to that moral influence which those of us who have learned the value of education ought to be exerting over others; to a true respect of man for man; for each man's right to judge what is morally best for himself and for those intrusted to him. It is an attempt to make one of those short cuts to progress which end by making the goal recede from us. It is an exaggerated idea—as exaggerated, ill-considered, and probably as short-lived as some other ideas of the present moment—of the value of book-education, founded on a rigid and official idea that home duties and labors must in all cases be put aside before the official requirements. It is a copy of a Continental institution, taken from a nation that, living under a paternal Government, has not yet learned to spell the letters of the word Liberty. The example of Germany and its highly organized state education is not alluring. In no country, perhaps, is there less respect of one class for the other class, or greater extremes of violent feeling. Where you subject people to strong official restraint, you seem fated to produce on the one side rigidity of thought and pedantry of feeling, on the other side those violent schemes against the possessions and the personal rights of the rich which we call socialism. Careful respect for the rights of others, vigorous and consistent defense of one's own rights, a deeply rooted love of freedom in thought, word, and action—these things are simply impossible wherever you intrust great powers to a Government, and allow it to use them not simply within a sphere of strictly defined rights, but as supreme judge of what the momentary convenience requires.

Secondly, get rid of all dependence upon the central department. If you do not as yet perceive that public money can not wisely, in any shape, be taken for education, still refuse the grant that the central department offers as a bribe for the acceptance of its mischievous interference. Until individual self-reliance has grown among us, let each town administer education in its own way. So, at least, we shall get local life and energy and variety thrown into the work, not the mere mechanical carrying out of regulations of two or three gentlemen sitting at their desks at Whitehall. But do not believe that you will get the highest results in this way. More freedom for action and experiment is wanted than you can get under any local board. Accustom yourselves to the idea that men will act better in voluntary groups than if forced into union by external power. Many boards acting freely in a town, and learning gradually to coöperate together to some extent and for some purposes, is what we should look forward to. Perhaps the best step in advance, and in preparation for a purely free system, is to obtain powers from Parliament under which any considerable number of electors, say from one sixth to one tenth, according to the size of the town, might elect, and pay their rate to, their own board. Under such a plan there would be imperfections and possible evasions ; but it would cast off the swaddling-clothes imposed by the Privy Council, and would give a life to the work which would far more than compensate for the loss of mechanical regularity. It is always difficult to introduce freedom into a system that is founded on authority and officialism. You can only escape from anomalies and contradictions by being either rigidly despotic or completely free. But a little life and light are worth getting at almost any price, and will make us wish for more. The final step will be to render the rate purely voluntary, and to give full freedom and responsibility of action, for which the people will never be fit as long as they are persuaded to subject each other to official regulations under the much-abused name of self-government.—*Fortnightly Review.*

HOW ANIMALS DIGEST.

By HERMAN L. FAIRCHILD.

IN reception of food, animals have been compared to plants turned outside in. The plant absorbs nourishment by pores in the foliage and rootlets. Higher animals absorb food by similar closed tubes which line a cavity of the body. This interior cavity, the food-tract or alimentary canal, is the most important and the most nearly universal organ of the animal structure. Its purpose is threefold—that of a reservoir, as animals can not always procure their proper food and can not, like plants, be ever eating ; a liquefier, as all food, both for plants and animals, must be in the fluid state; and, thirdly, a chemical laboratory, as nourishment must be like the body in composition. Plants have no need of such an organ, because the food is always at hand in proper condition. Consequently, food is not in the animal body proper when in the stomach. It is within the body, not of the body. It is only dead matter, under the control of the organic forces of the body, and preparing to become a substantial part of the living organism.

The several processes of animal digestion, mechanical, physical, and chemical, are simultaneously performed in varying degree throughout the whole length of the digestive tract. For our present purpose, however, it is more practicable to describe them separately. But that the division is arbitrary should constantly be kept in mind. The main part of mechanical digestion has already been described in the article on "How Animals eat."

Deglutition.—In animals which have the stomach some distance from the mouth or oral aperture, the swallowing of food is a distinct act, requiring special organs. The food must be forced through the connecting tube, known as the œsophagus or gullet. We do not find such in the lowest animals. The whole of nutrition is a single process in the tape-worm; with the amœba, grasping of food is not distinct from digestion; while in the anemone and jelly-fish the mouth opens directly into the stomach cavity.

If the stomach were always beneath the mouth, as in man and birds, food might with some difficulty reach the former by gravity. Birds do help the descent of food by jerking the head, and most birds in drinking lift the head each time the beak is filled. But animals must be able to swallow in spite of gravity, as commonly in eating the stomach is higher than the mouth. This is possible even in man, for the juggler drinks when standing on his head.

Deglutition is accomplished by a peculiar and beautiful involuntary action of the gullet. The walls of this tube are composed of two muscular layers, longitudinal and circular, which act in accord. Immediately in front of the bolus of food the walls are relaxed, while behind and around it the walls contract, thus urging the matter forward; and, "as it travels, the wave of contraction travels with it." This motion of the gullet is well shown in the neck of a horse when drinking. It is a similar action which propels the food through the entire length of the digestive canal—termed in the intestines peristaltic or vermicular motion. The mill-like action of the gizzard and the churning motion of the stomach are only phases of the same thing. By a reversed action of the gullet, the cud of an ox is thrown from the stomach back to the mouth.

To place the bolus of food within reach of the muscles of the gullet, there is in the highest animals a most complex arrangement of parts in the pharynx or back of the mouth. In mammals, the pharynx is a funnel-shaped cavity having seven openings. Here the gullet crosses the air-pipe; and, to keep food and drink from taking the wrong road, there is an effective system of valves. The parts act spasmodically whenever they are irritated by the pressure of solids and liquids.

Saliva is found in nearly all animals. Its universal office is to lubricate the food and so help it to glide easily along the pharynx and

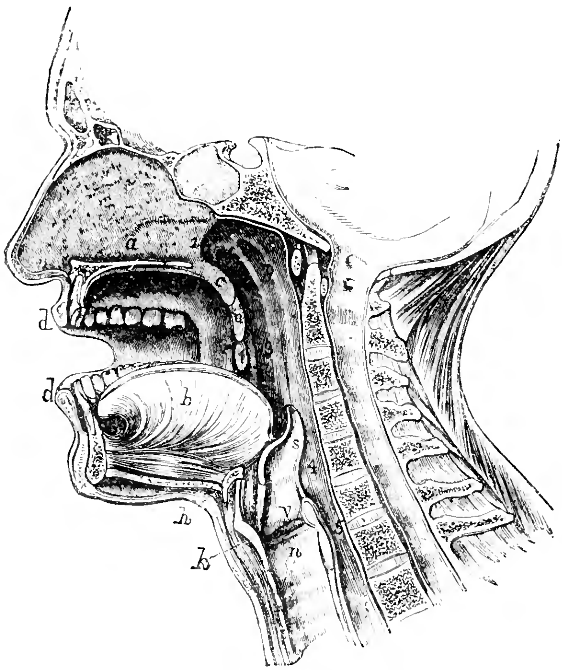


Fig. 1.—Median Antero-posterior Section of the Human Face: *a*, septum of nose, with section of hard palate below it; *b*, tongue; *c*, section of soft palate; *d*, *d*, lips; *u*, uvula; *r*, anterior arch, or pillar of fauces; *i*, posterior arch; *l*, tonsil; *p*, pharynx; *h*, hyoid bone; *k*, thyroid cartilage; *n*, cricoid cartilage; *s*, epiglottis; *v*, glottis; 1, posterior opening of nares; 3, isthmus faucium; 4, superior opening of larynx; 5, passage into œsophagus; 6, orifice of right Eustachian tube.

gullet. This kind of saliva is a glairy mucus, and is the only kind in animals which do not chew the food—for example, birds, reptiles, and fishes. As an aid to digestion, the saliva of mammals will be considered later.

The most astonishing feats in swallowing are performed by the snakes. The boa can certainly swallow a goat or deer. Our common little snakes, the size of a finger, can swallow a large frog, a performance sufficiently remarkable. The process is very slow and tedious, and one would suppose painful. The boa first kills its prey by crushing it in its tightening coils, which break down the ribs and limbs and reduce the victim to a shapeless mass. By this horrible proceeding the carcass is gotten into condition to be more easily swallowed. After coating it with mucus, the boa begins the difficult operation of forcing the huge mouthful down its throat. But how shall the act be accomplished with no limbs to assist? As the under jaw divides in front, and articulates with the skull by the intervention of extra movable bones, the mouth and throat can stretch enormously. The sharp, conical teeth are recurved, acting like the barb of an arrow to hold whatever position is gained. Each side of the jaw is pushed forward in turn and gains a new and further hold on the carcass, which by successive slight movements is slowly pulled head first down the gullet. The common striped snake seizes a toad or frog, however he can catch him, usually by one or both hind legs, and immediately proceeds to "take him in," despite all protests and struggles.

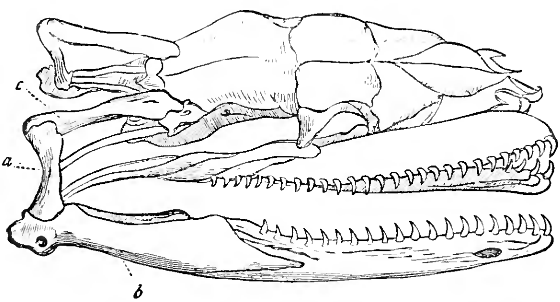


Fig. 2.—Skull of a Serpent (*Python*): *b*, articular portion of the lower jaw; *a*, quadrate bone; *c*, squamosal portion of the temporal bone.

As the opposite of the enormous throat of the snake, the bulky whalebone whale has the smallest throat, proportionate to its size, of any animal—just large enough to admit the tiny creatures which are its food. We see in this a fine example of Nature's economy.

The alligator has a curious way of preventing the admission of water when swallowing prey. Seizing a fish or other small creature, the reptile rises to the surface of the water and flings it into the air; then, before it reaches the water, catches it and gulps it down. If the prey is too large to handle in this manner, it is carried to the shore to be devoured.

Ingluviation.—Many animals can not procure their particular food at all times. Such either can endure fasting, like members of the cat tribe, or have a special reservoir, as shown in the crop of a fowl. This crop is only a dilatation of the gullet. In the cormorant, the whole gullet is very capacious, for the purpose of storing fish; on account of which habit the bird has become a type of voracity. The pigeon has its crop divided into two—perhaps to give a better form for flight. The pelican has a bag beneath the lower jaw. Many small animals, insects especially, have crops. Similar in purpose is the first stomach, or paunch, of a cud-chewer. Birds which eat fruit, insects, or other food readily procured, and of a character which needs no delay in digestion, have usually no crop, or but a rudimentary one.

While the whole digestive tract serves the purpose of a reservoir, the special reservoirs have indeed a digestive function, serving to delay the food, that it may be acted upon for a sufficient time by the chemical fluids. Thus the crop of a bird secretes a fluid which softens and prepares the hard grain for subsequent trituration and digestion.

Organs of Chemical Digestion.—As the organ of digestion proper is the one most nearly universal, it consequently affords the finest example of specialization and development. From the improvised cavity of the amœba, there is a steady progress by minute steps to the complex apparatus of the mammals. Digestion is not more perfect, however, in the latter than in the former. The simple nutritive act of the amœba is as perfect for itself as the differentiated process of the highest animals is for them. In the lowest animals, the function is single, and so simple that no special organ is necessary. As we rise in the animal scale, the function is divided into secondary functions, which require for their performance a corresponding number of special organs. Indeed, the complex functions of prehension, mastication, digestion, and circulation are only subdivisions of nutrition which begins in the lowest life as a single act. The present purpose, however, is not to trace the evolution of specialization of the digestive function further than to illustrate its general principles and methods, and present some of its peculiar and interesting features.

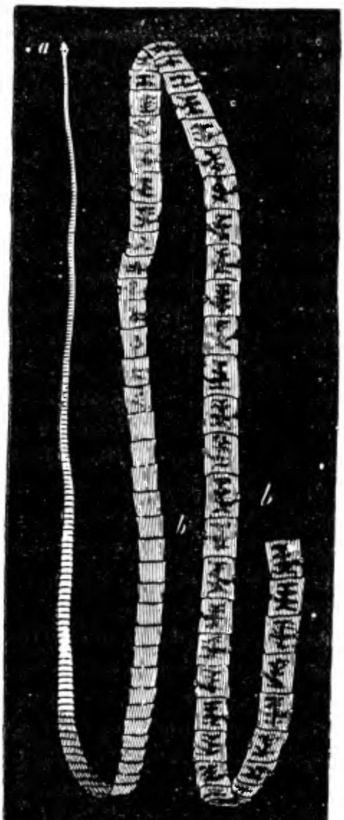
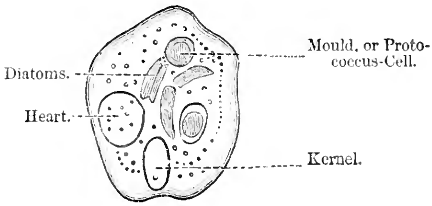


Fig. 3.—*Tænia solium*, or Solitary Worm: *a*, head, or scolex; *b*, tape formed of many individuals, the last of which, completely sexual, separate under the name of *proglottides*, and represent the adult and complete animal. Each solitary worm is a colony.

The tape-worm has no digestive organs whatever, having no use for them. A robber subsisting on the labors of its victim, it takes food in the same manner as a plant, by absorption from the outside. This is also the case with many lower protozoa.

The digestion of the amœba is only one remove higher than that of the tape-worm—with no permanent organs, but extemporizing a stomach from the skin as required. A step higher still we find the hydra, with a permanent body cavity serving the purpose of a stomach. But it is not distinctively a stomach, as it is the common organ of all the other vegetative functions. A single opening serves both to receive the food and expel the waste matter. Within even this narrow limit of structure, we find a host of low animals which exhibit a great variety of forms; so that from the hydra to the ctenophore is a progressive series showing a gradual specialization of this common



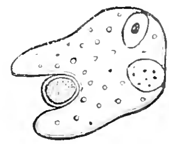


FIG. 4.
POND-AMŒBA DIGESTING ITS FOOD. AMŒBA EATING.

organ. In the higher part of the series, as for example the sea-anemone, there is a digestive cavity somewhat separated from the body cavity, though still connecting; and all the excretions have to find their way out through the oral aperture.

In the compound hydrozoans, produced by budding and division, such as sertularia and the so-called corals, the body cavity is continuous through the whole community. Hence each individual (though

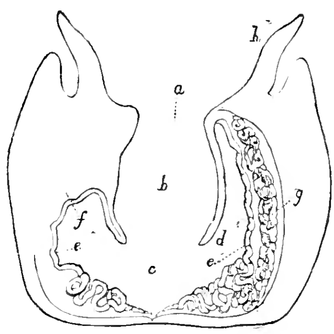


FIG. 5.—PERPENDICULAR SECTION OF *Actinia holsatica* (after Frey and Leuckart): *a*, mouth; *b*, gastric cavity; *c*, common cavity, into which the gastric cavity and the intermesenteric chambers open; *d*, intermesenteric chambers; *e*, thickened free margin, containing thread-cells of, *f*, a mesentery; *g*, reproductive organ; *h*, tentacle.

it is scarcely correct to regard it as such) has its stomach connected with the stomachs of all the others. Whatever food one digests serves to nourish the whole colony. They are absolute communists.

At this point should be presented the fact that in all animals the lining or secreting membrane of the food-canal is essentially but a continuation of the skin. That such is true of the amœba is evident, for what was the outside of the body-mass becomes when food is enveloped the lining of the new cavity. The cup-shaped body of the hydra can be turned inside out without interference with the business of digestion. The skin in these cases must have a chemical digestive power,

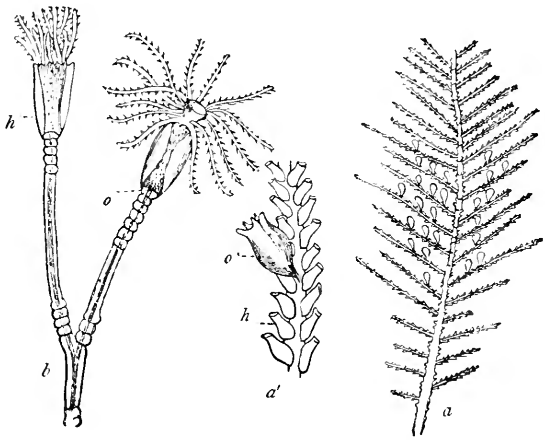


Fig. 6.—*a*, *Sertularia* (*Diphasia*) *pinnata*, natural size: *a'*, fragment of the same enlarged, carrying a male capsule (*o*), and showing the hydrothecæ (*h*); *b*, fragment of *Campanularia neglecta* (after Hincks), showing the polypites contained in their hydrothecæ (*h*), and also the point at which the cœnosarc communicates with the stomach of the polypite (*o*).

as the food taken in mass, and frequently living substance, or even whole animals, is dissolved without trituration or mechanical aid. The human skin has powers of absorption, and in some slight degree a person may be fed through it. The continuation of the skin which lines the digestive canal is supplied with new powers of secretion; so that, instead of producing perspirations, oils, etc., it manufactures chemicals for changing food. Hence the principle of digestion and the character of the organs are fundamentally the same in all animals, the lowest with the highest. Only in the amœba, hydra, etc., digestion is accomplished with the least possible expenditure.

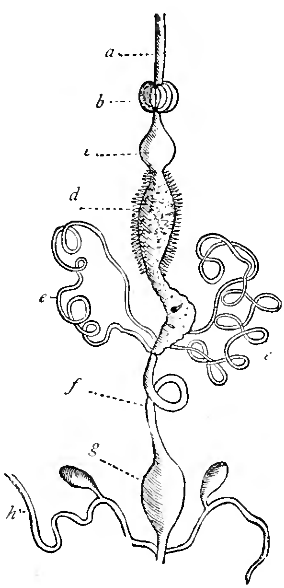


Fig. 7.—Digestive System of a Beetle (*Carabus auratus*): *a*, œsophagus; *b*, crop; *c*, gizzard; *d*, chylific stomach; *e*, Malpighian tubes; *f*, intestine; *g*, cloaca; *h*, supposed renal vessels.

A *true stomach* must be wholly devoted to the elaboration of food, leaving other functions to other organs. This requires that it be wholly shut off from other cavities of the body; and it were better to have two openings, one for reception of food, the other an outlet for waste matter, in order to give the food a single direction and prevent the mingling of digested and undigested matter. This perfect stomach is realized so gradually, or by such slight degrees, in a large number of lower animals, that it is not easy to say positively which animal has the honor of its first possession. To the little sea-urchin, which is the first possessor of true teeth, is generally given the credit. The ctenophore, a lower animal, has indeed two or more apertures to its food-cavity, but the mouth is still the main excretory orifice, and this cavity freely communicates with a system of body canals. The starfish, on the contrary, has the stomach distinct from the other cavities of the body, with, however, in most cases only a single opening.

In the sea-urchin we also find an intestine and indications of the several parts which are so distinct in higher animals. The sea-cucum-

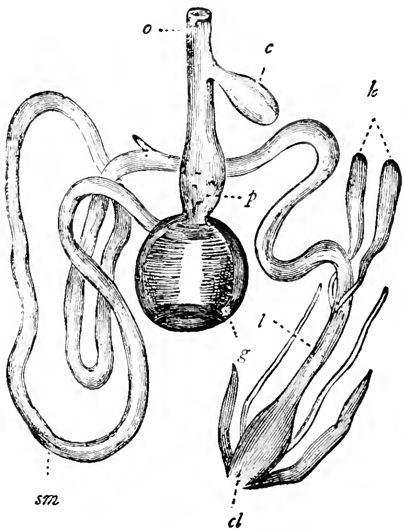


Fig. 8.—Digestive System of the Common Fowl (after Owen): *o*, gullet; *c*, crop; *p*, proventriculus; *g*, gizzard; *sm*, small intestine; *k*, intestinal cæca; *l*, large intestine; *cl*, cloaca.

ber, a near relative of the former but with a better digestive canal, is almost as highly favored regarding its stomach as the low amœba. If its stomach becomes troublesome from indigestion or other cause, it simply ejects it through the mouth, along with its other internal organs. Then it quietly awaits the growth of a new set—certainly a very happy and efficient method. Many human dyspeptics would rejoice in the same power. This animal is said to reject its viscera when it is injured or alarmed. This is interesting, as showing in the low animals that which is well known in the highest, the immediate effect of fear and pain upon the internal organs, or the close dependence of the nutritive organs upon the nervous system.

Among articulates and mollusks we find a great diversity in the character of the digestive canal. Its main divisions are always shown more or less distinctly. But in many articulates, as some worms, myriapods, larvæ of insects, and crustaceans, the tube is quite straight; while in others it is highly convoluted. Biting insects have all the parts ever found in the food-tract, namely, pharynx, gullet, crop, gizzard, stomach, small and large intestines. In some members of the spider family, the short and straight food-canal sends off branches into the limbs and other members. The absurdity of a creature carrying its stomach in its legs!

Many snails have crop and gizzard, as also has the nautilus. In snails the intestine passes through the liver, and in clams through the heart. Many butterflies take no food, and the digestive organs are entirely absent. In this case the eating and storing of nutriment was performed in the earlier larval state with excellent organs. But the male notommata, one of the rotifers, never has digestive organs; it lives its brief life upon the nourishment of the egg from which it was derived.

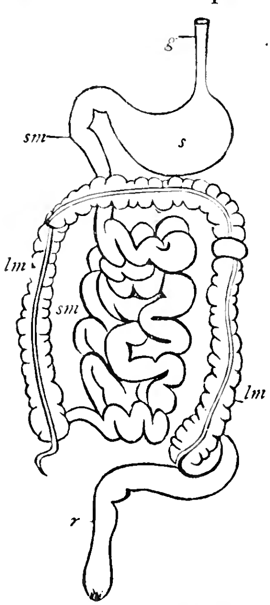


Fig. 9.—Diagram of the Digestive System of a Mammal: *g*, gullet; *s*, stomach; *sm*, small intestine; *lm*, large intestine; *r*, rectum, terminating in the aperture of the anus.

Fishes have a short and comparatively simple alimentary tube with generally a wide gullet, and seem commonly to disgorge indigestible substances. Reptiles usually have the parts more strongly marked. Tadpoles have a very long and greatly convoluted canal, but the vegetable-eating turtles have the longest. Crocodiles have a powerful gizzard, like birds, and are said to swallow stones to assist the trituration of food. They approach birds also in possessing a mesentery, a membrane which supports the food-tract and fastens it to the walls of the body. In all lower animals the canal lies loosely in the body cavity. The food-tract of birds varies in length and character according to the kind of food. The crop and gizzard have already been described, the latter in a former article.

In mammals the great body cavity is divided into two chambers, thorax and abdomen, by a transverse partition called the diaphragm. The gullet passes through and the stomach lies just beneath this membrane. The parts of the food-tract are always clearly marked, and the stomach is frequently divided. In all animals digestion is more prolonged in proportion as the food is unlike animal substance. With carnivorous mammals the process is simple. The whole length of the food-tract in members of the cat tribe is only about three times the length of the body. Man employs a mixed diet, and has the canal six times the length of the body. No food is less like flesh than herbage, consequently we find with such food the most difficult digestion. In ruminants the canal is over twenty times the length of the body; and the stomach is divided into four chambers, to delay the food and complete the mechanical process. The first two, however, are more properly expansions of the gullet. The first chamber, called the *paunch* or *rumen*, stores and moistens the half-chewed food. This division in the camel has a portion lined with cells for storing water. The second chamber, known as the *reticulum* or honey-comb stomach, receives this raw material, rolls and presses it into separate balls, which are sent up to the mouth for more perfect mastication. When this is complete, the now semi-fluid or pasty bolus, being unable to distend the aperture to the first and second chambers, flows into the third chamber. This has its lining greatly folded in order to detain coarse material, whence it is called *manyplies* or *psalterium*. The fourth chamber,

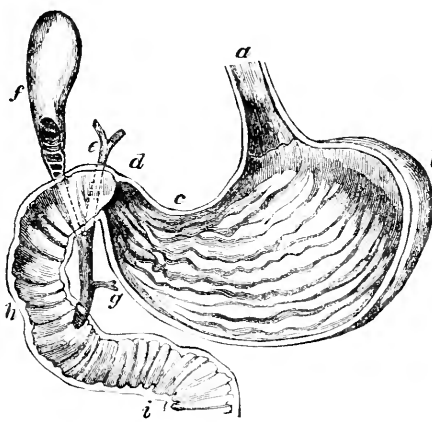


FIG. 10.—THE STOMACH LAID OPEN BEHIND: *a*, the œsophagus; *b*, the cardiac dilatation; *c*, the lesser curvature; *d*, the pylorus; *e*, the biliary duct; *f*, the gall-bladder; *g*, the pancreatic duct, opening in common with the cystic duct opposite *h*; *h*, *i*, the duodenum.

abomasum, is the stomach proper, as here alone is the food subjected to the gastric juice.

On account of defective mastication, the whales have at least three divisions of the stomach; many mammals have two divisions; and the toothless ant-eater has a gizzard.

DIGESTIVE FLUIDS.—After considerable investigation, the precise action of the several fluids which accomplish the chemical change of food is yet unknown. Indeed, their general function is still a matter in discussion. Naturally, then, our knowledge of the functions of the accessory digestive organs in the lower animals is limited. That digestion, however, in all animals is the result of chemical action under the influence of vital force seems assured.

Of the several fluids or chemical agents prepared within the laboratory of the digestive apparatus, the most important and indispensable is the gastric juice, the presence of which determines the location in the food-tract of the stomach proper. This is because the fluid is produced by the lining of the stomach, and not by a distinct organ. That even the microscopic animals have some digestive fluid, like gastric juice, is regarded as proved by the fact, already noticed, that solid food is dissolved by them without mechanical aid. This fluid is well shown in the radiated animals. Its active principle is a ferment called *pepsin*, which acts only in the presence of an acid. The acidity of the fluid is given by free hydrochloric acid. Gastric juice dissolves only nitrogenous substances, as meat, albumen, and gelatine, having little or no effect on oil or starch.

Next to the gastric juice in importance, if we may judge by its early appearance in the animal kingdom, is the bile. This alkaline fluid is found in all animals having a distinct digestive cavity. The earliest biliary organs are minute cells upon the stomach-lining, as in the anemone. A higher form is found in the small tubes surrounding

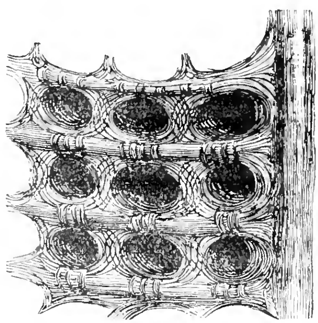


Fig. 11.—Water-cells of Camel's Stomach.

the intestines of the insect, from which there are slow gradations to the superior liver of the higher mollusks and fishes. In the articulates, mollusks, and all higher animals, the bile is poured into the intestine and so separated from the gastric juice. The action of the bile is not fully known; but it appears to dissolve fats slightly, and helps to subdivide them into minute particles which are "diffused through the liquid like atoms of butter in milk." It probably aids also in the process of absorption.

The pancreatic juice, another alkaline fluid, is found below the vertebrates only in the higher mollusks. As a gland the pancreas is rudimentary in the cephalopods, but appears better developed in the fishes, and proportionally largest in birds. The function of this fluid is a general one, as it acts on nearly all aliments, and seems to be the principal means of digesting oils and starch, or carbonaceous foods. It is poured into the small intestine near the stomach.

By the mucous lining of the intestines there is produced an alkaline fluid or fluids which are supplementary to the former. Thus we find digestive fluids secreted through the whole length of the food-canal.

Saliva is present in most animals as a lubricant for the food. But in those animals which chew the food there occurs another kind of saliva, a limpid fluid which aids mastication by softening the food. In mammals this has also a chemical power, changing starch to sugar. As the latter substance is heat-producing, this chemical energy is lacking in the cold-blooded vertebrates. In birds this saliva is replaced by the abundant pancreatic juice. It is most abundant in herbivores, as might be supposed from the fact that starch is a vegetable product.

ABSORPTION.—The dissolved and chemically altered food is yet to be taken into the body, and carried wherever needed, either to supply deficiency or produce growth. At present we have to do only with the first process. In some degree the food is absorbed, as fast as digested, by blood-vessels through the whole alimentary tract. This is true particularly of the stomach. But in vertebrates absorption is

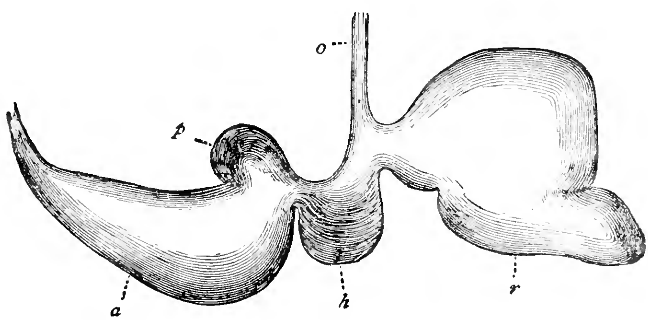


FIG. 12.—STOMACH OF A SHEEP; *o*, gullet; *r*, *rumen*, or paunch; *h*, honeycomb-bag, or *reticulum*; *p*, manyplies, or *psalterium*; *a*, fourth stomach, or *abomasum*.

chiefly by minute tubes, called lacteals, which line the intestines. After passing through certain glands, these tubes unite to form a single tube known as the thoracic duct, which pours its contents into the veins in the neck.

In the higher invertebrates the blood-vessels take up all the nutriment directly from the digestive canal. In the lower, the food as fast as digested passes directly through the walls of the canal into the tissues; while in the lowest animals, where the digestive cavity communicates with the body cavity, the food freely bathes all parts of the structure. Simpler still, in the case of the tape-worm absorption is all the creature has to do.

Whether the process of absorption is wholly physical or partly vital is disputed. But some time during the process, or immediately afterward, the food is changed from merely dead substance to vitalized organized matter, and it is now ready to form part of the living tissues.

THE SOLAR SYSTEM AND ITS NEIGHBORS.*

By C. B. WARRING, Ph. D.

ASTRONOMERS say that this world of ours, which seems to us so large, is in fact so small in comparison with the sun and stars, that its presence or absence is, to the universe, a matter of inconceivably small importance; and that, even in its own system, it would hardly be noticed by an eye capable of taking in at one view the sun and its attendant planets.

Sir John Herschel gives the following illustration of the size and distance of these bodies: "Choose," he says, "any well-leveled field. On it place a globe two feet in diameter; this will represent the sun; Mercury will be represented by a grain of mustard-seed on the circumference of a circle 164 feet in diameter for its orbit; Venus, a pea in a circle of 284 feet in diameter; the earth, also, a pea on a circle of 430 feet; Mars, a rather large pin's head in a circle of 654 feet; Jupiter, a moderate-sized orange in a circle nearly half a mile across; Saturn, a smaller orange on a circle of four fifths of a mile; Uranus, a full-sized cherry upon the circumference of a circle more than a mile and a half; and Neptune, a good-sized plum on a circle two and a half miles in diameter."

If our earth were struck out of existence, it would hardly be missed from such a system. But this is far from the extreme measure of our littleness. The evening sky is studded with stars. Between us and them is empty space. As we look across it, the distance does not seem so very great, and even astronomers were long in learning how great it is, and how utterly isolated the sun with its train of planets is from even the nearest star. Keeping the same scale as before, in which our inconceivable distance from the sun, 92⅓ millions of miles, was reduced to a dozen rods or so, and then setting out to visit our neighbors, if we are lucky enough to turn our steps to the nearest, we find before us a journey of nearly 9,000 miles. Had we directed our course to any other of the stars, our road would have been many thousand miles longer. There are stars from which light requires 6,000 years to reach our globe!

Had we gone toward one of them, our journey on the same infinitely reduced scale would have taken us nearly 18,000,000 miles before reaching our goal.

Even this scale gives distances too vast. Let it be changed. Let the sun shrink to a point $\frac{1}{100}$ of an inch in diameter. The distance to the sun, 92⅓ millions of miles, would be reduced to nearly one inch. The earth would be only $\frac{1}{10000}$ of an inch in diameter, requiring

* Read, January 13, 1880, before the Poughkeepsie Society of Natural Science.

1,000,000,000,000 times its bulk to make a globe one inch in diameter. On such a scale our world would be equaled in minuteness only by the animalcules which the microscope reveals. Even then, on this inconceivably reduced scale, the line that would reach our nearest neighbor would need to be something more than three miles long.

Yet that sun, which in this estimate we have mentally reduced to a point $\frac{1}{100}$ of an inch in diameter, is in reality a body so vast that, were it hollow, and our earth placed at its center, the moon would not only revolve freely around our planet, just as it now does, but on every side the sun would extend more than 200,000 miles beyond the lunar orbit. We have heard so often of the distance from here to the sun, 92⅓ millions of miles, that we begin to think we have some idea of its inconceivable greatness. Yet, so large is the sun that only 107 such bodies, laid so as to touch each other, would be needed to form a continuous bridge from the earth to that luminary. In the sky it appears so small that we find it difficult to realize that scarcely more than 100 times its diameter would reach so far.

However many of us may have sought, by these or by other illustrations, to form some conception of the vastness of the universe, but few have attempted to grasp the measure of that power which compels the planets to move in elliptical orbits instead of flying off in tangents, as, if left to themselves, they would inevitably do; and still fewer have thought of the force with which these bodies tend to pull one another out of their courses. Of these influences astronomers have given no illustrations, yet their contemplation will lead to results that will enlarge our views of the universe, and help us to rise at least a little toward a conception of Omnipotence.

We must work out our conclusions ourselves. The data are all at our hand. We need only to know the distances and masses; the rest is a matter of easy computation. But that our results may not be meaningless from their very greatness, it will be wise to follow the method which we pursue when trying to get an idea of great distances. We take first some unit with which we are familiar—for instance, a mile—and think how many miles it is to some place familiar to us. Then we extend that measure, or some multiple of it, to another place more remote, and then to one still more distant; and thus by degrees we become able to grasp distances whose statement in figures had previously conveyed little or no meaning to our minds. So, in measuring a force, we get a better idea of its greatness if we work up to it in a similar manner.

Of all known substances steel is the most tenacious. If the interplanetary forces can be represented by steel bars of known size, it will at least help to bring them within the limits of our comprehension.

Philosophers have found that a steel wire one tenth of an inch in diameter will support nearly half a ton, while a bar one inch square will not be pulled asunder by less than sixty tons. If two inches square, it will require 240 tons; if three inches square, it will scarcely break with 540 tons. Bars of steel are not often made larger than this, although Krupp, in his colossal works, doubtless makes some whose section equals 144 square inches. To pull apart such a bar would require a strain equal to the weight of 8,640 tons. It requires an effort to grasp the meaning of such a load. A stout team will haul two tons over a good road for a moderate distance; that number of tons would require more than 4,000 such teams to move it. If put upon a railroad it would need 864 cars and twenty-three locomotives to draw it. It would equal in weight one of the largest ocean-steamers with its complement of freight.

But we shall need a much larger unit than this. Could a bar of steel three feet square be forged—and, judging from the size of his steel cannon, Krupp might do this also—it would be able to lift nine times that great amount. Probably no furnace can much exceed this, but we may imagine a monster bar measuring one rod—16½ feet—square, and by easy multiplication we find its strength great enough to lift 30¼ times as much as the last, or in figures 2,352,240 tons, three times the weight of the cotton crop of the United States when it equaled 4,000,000 bales.

To get a fit unit for our purpose we shall need to go far beyond this, but first pause to contemplate a bar of steel 16½ feet square. As it lay stretched upon the ground, we would need a ladder to get upon its upper side. Few rooms in private dwellings are 16½ feet high, and 16½ feet wide makes a spacious parlor.

Endeavor to get some idea of its tenacity, and how many million horses it would require to pull it asunder, and then, after getting somewhat accustomed to the greatness and strength of a bar of solid steel 16½ feet square, imagine one which is one mile square—5,280 feet wide, and as many thick. If it lay on the ground near the Catskill Mountains, its upper surface would overtop their highest summit by more than 1,000 feet. It would be equal to 102,400 such monster bars as the last. Its lifting power would be nearly 240,869,000,000 tons. The mind is utterly unable to grasp such figures. The whole globe contains 1,200,000,000 inhabitants. If each man, woman, and child, could pull with a force of 100 pounds—a large estimate—to move such a weight would require the united efforts of the inhabitants of two thousand such worlds as this.

As I shall have frequent occasion to speak of the load which such a bar could sustain, I shall, for convenience, call it in round numbers 240,000,000,000 tons, neglecting the other figures, because the number is so inconceivably great that taking from it a billion or so of tons will alter the result less than one half of one per cent. This bar is to be the unit of measure which I shall for the present employ, and with its help I shall attempt to give some idea of the influence of the sun in holding the system together, and of the attraction exerted by the planets upon our earth, and by the earth upon the moon; and, lastly, by the fixed stars upon the sun and upon each other.

We begin with the moon because it is nearest to us, and, with the exception of the sun, is to us the most important of all the heavenly bodies.

If a half-dozen persons were asked how large the moon appears, they would give as many different replies: "The size of a cart-wheel"; "Twelve inches across"; "The size of a dining-plate"; "As big as a man's head," etc. Probably no one would mention a smaller measure, yet a cherry held at arm's length much more than covers its disk. It is difficult to believe that so small a body exerts any considerable influence on the earth which seems so immensely larger. It is easy enough to admit that the earth holds the moon in its orbit; but, that to do this, to bend its course into a nearly circular orbit, requires any great outlay of force, is not so clear. Our credulity would be taxed were we asked to believe that the moon in its efforts to move in a straight line would break away, although held by a bar of steel one foot square, for that means a force able to lift nearly 9,000 tons. An astronomer would grant it, making first a mental calculation to see if he were justified in doing so; but even he would hesitate, and perhaps would deny that it was possible the moon could pull asunder one of those great unit-bars one mile square, and equal to more than 27,000,000 bars each one foot square.

But he would have no hesitation in saying, "Impossible!" if told that, rather than change its course from a straight line to its present curve, our willful little satellite would snap like pack-thread not one, nor two, nor three of those unit-bars, but the united strength of 10,000—or, in other words, one gigantic bar whose section is 100 miles square. Yet, more than eight such bars, or, more precisely, 87,500 unit-bars, would but barely deflect the moon into its present path.*

You will say, "This is too much—no one will believe it!" Let us see. A few astronomical facts, with a very small amount of mathematics, will suffice to show that there is no exaggeration here. One need know only the weight of the earth and moon, and their distance apart, and the law that gravitation grows less as the square of the distance increases, and he has all the elements required for the calculation.

The weight of the earth is found by an experiment described in almost every school philosophy. It consists in comparing the attraction exerted by a ball of lead of known weight with that exerted by the earth. In this way the earth's weight has been ascertained to

* The non-astronomical reader may, perhaps, need to be reminded that the moon does not move easily and naturally in a circle—or ellipse—but that its path, if left to itself, would be a straight line—a tangent to its orbit. Consequently, the moon requires to be forced into a curve.

be in round numbers 6,000,000,000,000,000,000,000 tons, or, as it is more conveniently written, 6×10^{21}, where the 21, of course, denotes the number of ciphers after the 6. The moon's mass is nearly one eightieth ($\frac{1}{81}$) as great, or, in other words, if it lay upon the surface of the earth, it would weigh 75,000,000,000,000,000,000 tons (75×10^{18}). This, however, must be diminished because the moon is, in fact, sixty times farther off, measuring in both cases from the center of the earth. Dividing, then, the moon's weight by the square of 60, or 3,600, we have for the weight at its actual distance something more than 21×10^{15} (21,000,000,000,000,000) tons after adding one eightieth for the attractive power of the moon itself, for there is a mutual attraction.

To get, then, the number of unit-bars necessary to equal this effect, we have only to divide the weight of the latter by the amount which one of these bars will sustain. That is, we divide 21×10^{15}, by 24×10^{10}, and find the quotient to be 87,500, which agrees with our statement.

It will be interesting to stop here, and endeavor to get some faint idea of what these enormous numbers mean. A bar of steel whose section is 87,500 square miles would include within its four sides a territory as large as that of New York State, and still leave enough to cover the State of Ohio, with a surplus of 536 square miles for good measure. We read in a certain book of a traveler who, coming into Lilliput, was held immovable by thousands of tiny threads. If a web of steel were stretched from the earth to the moon to hold our satellite from flying off into space, each tiny thread being represented by a bar of steel one fourth of an inch square—no trifle, for each could hold 7,500 pounds—they would cover our globe on the side toward the moon with a network whose threads would be only six inches apart, and through which none but the smallest animals could pass.

It may aid us, while seeking to grasp such a force, if we reflect that the very small difference between the moon's pull upon the ocean and that upon the earth's center suffices to lift the tides; how vast, then, must be the whole pull upon the earth!

All this inconceivably great force is needed to bend our satellite's course from the straight line in which it would move if left to itself. This force is exerted, not once for all, as in case of the original impulse that sent the moon forward in its path, but afresh every second; for otherwise, after such an indrawing, it would move thenceforth in a straight line. To give a circular orbit, the direction of the moon needs to be changed every moment, and this requires a series of impulses.

Thus much for our earth's satellite. We may extend our reasoning to more distant bodies. The earth is 81 times the mass of the moon; the sun is 315,000 times the mass of the earth, and something more than 381 times as far from it as we are from the moon. Combining these in an easy calculation, we find that the sun puts forth upon our earth a coercive force to bend its path into an ellipse, a force to be measured by 15,000,000 of our unit-bars, together making a bar of solid steel whose section would cover 15,000,000 square miles, more than four times the area of the United States. The wires, such as we supposed to hold the moon, would, in the case of the earth and sun, be almost as close as the blades of grass on a lawn.

Without going any further into calculations, it is enough to say of the other planets, that Mercury is held to its duty by 6,590,000 of our unit-bars; while Venus, being nearly as large as the earth, and so much nearer the sun, requires the united strength of nearly 23,000,000. Mars is smaller, and more remote, and therefore needs only some 811,500 such bands to hold it to its course; for, strange as it may appear, and however unlike other sovereigns, the sun holds its subjects in obedience the more easily, the greater their distance from the center of the system, provided, of course, that their importance otherwise is the same. But still, distant as it is, Jupiter's immense mass demands incomparably the strongest measures to keep it in check; nothing less than 170,000,000 of those bands of steel will overcome its wandering tendencies. Saturn, being a lighter weight, is more easily guided—15,000,000 suffice for that. Uranus and Neptune are of little account as compared with Jupiter; 588,000 for the one and 282,000 for the other are all that are needed to restrain their vagaries.

If, now, we turn to the planets, and study their influence, we shall find them pulling and tugging at each other with forces that, but for compensations planted in the system itself, would tear it to pieces; but, like the armed men of Cadmus, these forces destroy each other.

However difficult it may be to conceive of such an amount of power as the sun puts forth, we are so accustomed to regard that body as the governing center of our part of the universe, and have heard so much of its vast size, that we are prepared to accept almost any statement in regard to it. But as to the planets we do not realize their size, and we seldom think of their exerting any influence on the earth or on one another. That they do exert such an influence we know, for astronomers have told us of perturbations thus produced; but, then, very few of us connect such statements with the tiny specks which we see in the heavens. Yet their influence is no trifle. Mercury, which is too small and too near the sun for most of us to have seen, draws the earth when in mean perigee with a force small indeed when compared with those which we have been considering, but large enough to break 232,390,000 bars one foot square; Venus pulls with a force of 11,175,000,000; Mars pulls enough to overcome the united strength of 590,680,000; while Jupiter draws away with a steady tug of nearly 23,000,000,000; and even Neptune, 2,700,000,000 miles away, and utterly invisible to the naked eye, still has sufficient energy to drag our earth toward it with force able to snap 27,000,000 such bars. Besides these, which are only the interplay of forces between our globe and its sister planets, a similar action is constantly going on between each planet and all the others. The mind is lost in such a labyrinth of forces, and almost refuses to proceed. But we have only entered upon the vestibule of the mysteries of the universe. Across that gulf which separates our system from the stars, unseen hands with sinews strong as steel are extended to bind all into one great whole. From each star reaches out to our sun a force, small as compared with those which hold our system together, yet of a size that will amaze us. To the nearest of these far-off suns the distance is so great that light, which travels almost 200,000 miles in a second, requires three years to traverse it! Yet gravity reaches across that gulf with a speed which, if not absolutely instantaneous, is, according to Laplace, 50,000,000 times greater than that of light. Such a distance reduces proportionably the attraction; yet our sun with its attendant planets is drawn by mutual attraction toward the nearest star, supposing them to be of the same size, with a force great enough to break a cable, each of whose strands, 236 in number, should be a solid bar of steel one mile square; or, if we change our scale, and employ such bars as those used when speaking of the interplanetary forces, bars of steel one foot square, then the attraction between the nearest tiny speck of light and our sun would be equal to the united strength of 6,500,000,000 such bars.

When we remember that each star, however remote, adds its quota of force, and that a star whose light requires 6,000 years to reach the earth is linked to our system by a band able to lift more than 14,000,000 tons, we may well believe that our system is being hurried through space in a path which is the resultant of innumerable forces.

The force which thus impels our sun reacts on other suns, and they on each other, and thus all are in movement. This is not a conclusion drawn from mere theorizing; the measurements of astronomers have established the fact that the "fixed" stars are moving with enormous velocities, not, as has often been said, about a common center, but in directions which cross each other at all angles. Millions of years hence these movements will result in the destruction of the present universe, unless He who called the stars into existence shall lay his hand upon them. If, as revelation and science both teach, not a sparrow falls to the ground without his knowledge, surely suns and worlds shall not perish without his consent. He who in the beginning created the heavens and the earth will guide them to the end.

LEGAL PROSECUTIONS OF ANIMALS.

By WILLIAM JONES, F.S.A.

AMONG the strange practices of olden times nothing can be conceived more truly absurd than the trial, by legal proceedings, of animals accused of high crimes and misdemeanors, which prevailed, more or less, from the twelfth to the seventeenth centuries, and present a curious picture of the habits of thought during those periods.

The trials in question were conducted with all the solemnity of the law. In every instance advocates were assigned to defend the animals. Domestic animals were tried in the ordinary criminal courts; wild animals of a noxious description, such as rats, locusts, caterpillars, and such like, were subjected to the ecclesiastical courts. The first excommunication fulminated against animals is recorded in the twelfth century. St. Foix, in his "Essais Historiques sur Paris," states that the Bishop of Laon pronounced in 1120 an injunction against the caterpillars and field-mice, on account of the ravages they made on the crops.

The mode of trial in the criminal courts was this: The accused animal was committed to prison; the *procureur*, or officer who exercised the functions of prosecutor at the court, after hearing witnesses and taking down their depositions, and the crime of homicide being proved, the judge condemned the animal to be strangled, and hung by the back-legs to an oak-tree, or a gibbet, according to the custom of the country. In the case of damages done to property, the inhabitants of a district suffering therefrom, experts were appointed by the court to survey and report on the subject. A lawyer was then appointed to defend the animals, and show cause why they should not be summoned before justice. They were then called three times, and, not appearing, judgment was given against them in default. The court then issued an admonition, warning them to leave the district within a certain time, at the expiration of which, if they were still contumacious, they were to be anathematized with all due solemnity. Instead, however, of feeling the effects of this terrible sentence, it is recorded that in some instances the noxious animals, contrary to "withering off the face of the earth," became more abundant and destructive. This the lawyers attributed neither to the injustice of the sentence, nor want of power of the court, but to the machinations of Satan, who, as in the case of Job, is at certain times permitted to tempt and annoy mankind.

From the thirteenth to the sixteenth century there are numerous examples of proceedings in the criminal court in the case of pigs (and sows, more particularly) who had devoured children. As one may see at present in certain localities, these animals in the middle ages ran about the streets of villages, and were, it would seem, more addicted to a liking for human flesh than, happily—grace to the refinements of time—they are now. In the "Annuaire du Département de l'Aisne" (1812) are full details of the sentence pronounced on a hog (June 14, 1494) by the Mayor of St. Martin de Laon, for having *défacié* and strangled a child in its cradle. The sentence concludes thus: "We, in detestation and horror of this crime, and in order to make an example and satisfy justice, have declared judged, sentenced, pronounced, and appointed, that the said hog, being detained a prisoner and confined in the said abbey, shall be, by the executioner, hung and strangled on a gibbet near and adjoining the gallows in the jurisdiction of the said monks (of St. Martin de Laon), being near their copyhold of Avin. In witness of which we have sealed this present with our seal." This was done on the 14th day of June, in the year 1494, and sealed with red wax, and upon the back is written, "Sentence on a hog executed by justice, brought into the copyhold of Clermont, and strangled on a gibbet at Avin."

In 1497 a sow was condemned to be beaten to death for having eaten the chin of a child belonging to the village of Charonne. The sentence declared that the flesh of the sow should be thrown to the dogs, and that the owner of the animal and his wife should make a pilgrimage to Notre Dame de Pontoise, where, being the day of Pentecost, they should cry "Mercy!" after which they were to bring back a certificate. The execution of these animals was public and solemn; sometimes they were clothed like men. In 1386 the judge at Falaise condemned a sow to be mutilated in the leg and head, and afterward to be hung, for having torn the face and arm and then killed a child. This was a Draconian method of punishment. This sow was executed in the public square, clothed in a man's dress. The execution cost ten sous, six deniers tournois, besides a new glove for the executioner.

Bulls shared with swine the same mode of trial and punishment; horses, also, guilty of homicide had a similar ordeal. The registers of Dijon record that in 1389 one was condemned to death for having killed a man.

In the "Mémoires de la Société Royale Académique de Savoie" is a singular account of the law proceedings, instituted in 1587, against a species of beetle that made great ravages in the vineyards of St. Julien, near St. Julien de Maurienne. In 1545 these insects had made an irruption into this territory. Two lawyers had been selected, one by the inhabitants, and the other to defend the animals, and, wonderful to relate, the beetles suddenly disappeared, and the lawsuit was accordingly abandoned. It was, however, resumed forty-two years afterward, in 1587, when they reappeared and committed great ravages. The court addressed a complaint to the vicar-general of the Bishop of Maurienne, who named a judge, and also a lawyer to plead for the insects, and published an order prescribing processions, prayers, etc. After several legal discussions the inhabitants of St. Julien were informed that it was necessary to provide a piece of land outside the vineyards, where the beetles could live without infringing on the vines. The land was to be of a certain extent, and to contain trees, herbs, etc., in sufficient quantity, and of good quality. The concession was made June 29, 1587, and on July 4th the counsel for the inhabitants presented a request to the court that, in default of the defendants accepting the offer, the judge would order the vineyards to be respected under certain penalties. The advocate for the animals demanded time for deliberation, and, the trial being resumed in September following, he declared that he could not accept on the part of his clients the offer that had been made to them, inasmuch as the locality in question was barren and did not produce anything. This was denied on the other side, and arbitrators were appointed to decide the question. The result is not known, as the manuscript containing the case leaves off at this point, but sufficient particulars have been given to show the extremely absurd and curious proceedings on this subject.

No district could commence a legal process of this kind unless all the arrears of tithes were paid up to the Church, and this circumstance gave rise to the well-known French legal maxim, "The first step toward getting rid of locusts is the payment of tithes." It seems that the clergy and the lawyers agreed very well together in these matters. Chasseneuz, a celebrated lawyer of the sixteenth century, writing on the subject of trying animals by law, in order to console the Beaunois for the plague of locusts (vulgarly called *huberes*), informs them that the creatures of which they complain were nothing in comparison to those that infested India. These last were no less than three feet long, and their legs were armed with teeth so powerful that saws were made of them! The best means of deliverance was to pay promptly and truly the tithes of the Church, and to cause a female (barefooted) to walk round the infected place.

The same means indicated by the lawyer for the inhabitants of St. Julien de Maurienne were employed very often, and successfully, according to some writers; thus, a famous councilor of Zurich, Félix Malléolus, or Hemmerlin (died 1457), relates that Guillaume de Saluces, who was Bishop of Lausanne from 1221 to 1229, ordered the eels of Lake Leman to confine themselves to a certain part, from which they were not to go out. He relates, also, that in the diocese of Constance and in the neighborhood of Coire were consigned, "en une région forestière et sauvage," larvæ and Spanish flies, that had been previously cited before the provincial magistrate, who, "taking into consideration their youth and diminutive size, appointed an advocate to defend them."

The summonses against offending animals were served by an officer of the criminal court, who read these citations at the places frequented by them. Though judgment was given by default on the non-appearance of the animals summoned, yet it was considered necessary that some of them should be present when the citation was delivered; thus, in the case of the leeches tried at Lausanne, a number of them were brought into court to hear the document read, which admonished them to leave the district in three days. The citation contained a description of the animals; thus, in a process against rats in the diocese of Autun, the defendants were described as dirty animals in the form of rats, of a grayish color, living in holes. This trial is famous in the annals of French law, for it was on that occasion Chasseneuz (who wrote a work in 1588, on the excommunication of animals), the famous advocate, won his first laurels. The rats not appearing on the first citation, Chasseneuz, their counsel, with true legal subtilty, argued that the summons was of a too local and individual character; that, as all the rats in the diocese were interested, all the rats should be summoned. This plea being admitted, the curate of every parish in the diocese was instructed to summon every rat for a future day. The day arriving, but not any rats, Chasseneuz declared that as all his clients were summoned, including young and old, sick and healthy, great preparations had to be made, and an extension of time was necessary. This also being accorded, another day was appointed, and again no rats appearing, Chasseneuz objected to the legality of the summons under certain circumstances. A summons from that court, he argued, implied full protection to the parties summoned, both on their way to it and their return home; but his clients, the rats, though most anxious to appear in obedience to the court, did not dare to stir out of their holes on account of the number of evil-disposed cats kept by the plaintiffs. Let the latter, he continued, enter into bonds, under heavy pecuniary penalties, that their cats shall not molest my clients, and the summons will at once be obeyed. The court acknowledged the force of this plausible plea, but the plaintiffs refusing to be bound over for the good behavior of their cats, the period for the attendance of the rats was adjourned *sine die*, and thus Chasseneuz and his clients came off victorious.

The "Conteur Vaudois" of Lausanne publishes this strange story, which is found in the "History of the Swiss Reformation," by De Ruchat. It is not inserted as a joke, but given in sober seriousness: In 1479 the vicinity of Lausanne was infested by cockchafers; a lawsuit was commenced against them, and three processions of the inhabitants ordered. The insects were cited to appear in the bishop's court, and for counsel they had assigned to them one Perrodet, who had been dead six months! The accused and their advocate not appearing, judgment was given by default. The sentence is in Latin, and is preserved in the archives of Lausanne. The insects are excommunicated in the name of the Holy Trinity and the Blessed Virgin, and they and their descendants were ordered to quit for ever the diocese of Lausanne!

The work of De Ruchat contains another strange story. In 1364 the church of Chuttens, in the Jorat Hills, possessed a miraculous image of St. Pancrace. A pig having destroyed a child, this image was brought out, and the child was restored to life. The pig was cited to appear in the bishop's court, and, being found guilty of willful murder, was sentenced to death. De Ruchat adds that the executioner was a pork-butcher.

With an abundant share of exorcisms, charms, and enchantments for the extirpation of vermin in olden time, England does not appear to have enjoyed the notoriety of the legal proceedings against animals which we have recorded as prevalent in foreign countries. There is, however, a curious case of the trial of a dog in 1771, near Chichester, which gave rise to a facetious parody, "A Report of the Case of Farmer Carter's Dog, Porter," by Mr. Long, a lawyer, who died in 1813. Home, in his "Every-day Book" (vol. ii.), gives an account of this mock trial, somewhat abridged from the original pamphlet in his possession, but without other alteration, together with a portrait of the dog Porter in the dock. The names of the parties engaged in the real trial are given, with those of the nicknames in the parody. The former are Butler, Aldridge, Challen, and Bridger, understood by the names of J. Bottle, A. Noodle, Mat o' th' Mill, and O. Ponser.

In Lord Fountainhall's "Chronological Notes of Scottish Affairs," a curious affair is mentioned in connection with the boys of Heriot's Hospital in 1681–'82, the year in which the Earl of Argyll was tried and convicted of high treason for refusing the test-oath without certain qualifications. The hospital boys made a mockery of the reasoning of the Crown lawyers on this subject. They resolved among themselves that the house-dog belonging to the establishment held a public office and ought to take the test. The paper being presented to the mastiff, it refused to swallow the same unless it was rubbed over with butter. Being a second time tendered, *buttered*, the dog swallowed it, and was next accused and condemned for having taken the test, with a qualification, as in the case of Argyll!

Charms and exorcisms for the dispersion or destruction of noxious animals prevailed from a remote period, and some of the superstitions, in a modified sense, still exist in our own country, and especially abroad. In the middle ages, history makes frequent mention of the calamities caused by plagues of insects. These were the more destructive, as agricultural science, almost in its infancy at that period, offered few remedies for preventing or mitigating the ravages. Recourse was consequently had to the assistance of the clergy, who listened to the complaint, interposed with prayers, and anathematized those enemies of mankind as the work of Satan. Thus St. Mammet, Bishop of Vienne, exorcised certain devils who had taken the figures of wolves and pigs, and had devoured children. Gregory of Tours (573–595) alludes in his "History" to talismans against mice, serpents, and conflagrations.

The suits against animals not unfrequently led to more serious trials of human beings on charges of sorcery. Simple country people finding the regular process very tedious and expensive, purchased charms and exorcisms from empirical, unlicensed exorcists at a much cheaper rate, but, if any of the parties concerned in this contraband traffic were discovered, death by stake and fagot was their inevitable fate. Still there was one animal, the serpent, which, as it had been cursed at the earliest period of the world's history, might be exorcised and charmed (so that it could not leave the spot where it was first seen) by any one, lay or cleric, without the slightest imputation of sorcery. The formula ran thus: -"By him who created thee, I adjure thee that thou remain in the spot where thou art, whether it be thy will to do so, or otherwise; and I curse thee with the curse with which the Lord hath cursed thee."

In the seventeenth century the cases of law proceedings against animals became rare, for the Church at this period had almost renounced these absurd practices. Thus, for example, in the "Ritual of Evreux," of 1606, Cardinal Duperron declares that no one should exorcise animals nor use prayers and formulas without his express permission. But the delusion was too widespread to be restrained. In Spain and Italy exorcists abounded, as in France. Azpilcenta, of Navarre, a distinguished Spanish canonist, asserts that rats when exorcised were ordered to depart for foreign countries, and would march in large bodies to the seacoast, and thence set off swimming in search of desert islands. Father Manoel Bernardes, in his "Nova Floresta" (published at Lisbon, 1706–1708), gives a long account of the trial of ants in Brazil in the commencement of the eighteenth century. The particulars are too long to be given in detail, but it appears that the monks of St. Anthony complained of the sacrilegious behavior of certain ants that ate their grain, and otherwise misconducted themselves, devouring the cloths of the altar, and bringing into the church pieces of shrouds from the graves beneath the church. The sentence was that the friars should provide a suitable place for the ants to remove to, which seems to have satisfied the defendants—*it nigrum campis agmen;* millions of ants immediately came out, forming themselves in long, dense columns, and proceeded direct to the field assigned to them.

In America birds of prey and insects were excommunicated. The Baron de la Houtan, who toward the end of the seventeenth century passed several years in Canada, relates that "the number of turtle-doves was so great in that country that the bishop was obliged to excommunicate them several times on account of the damages done by them." A similar infliction was pronounced in Peru against the *termites*, a species of white ant, that had got into a library and devoured a great number of books. In the "Voyages of La Perouse," it is stated that millions of cockroaches got into the bread-room, and recourse was had to exorcisms more than once.

The ceremonies attending the exorcism of animals were sometimes accompaned by a loud clashing of musical instruments: thus, it is mentioned in the "Life of St. Patrick," that he was unable with the most formidable interdicts to drive away a cloud of bats that had been taken for demons; but what his formulas could not effect was done by a deafening sound of cymbals, which drove them away, as may well be imagined, in great affright. The greatest of the numerous miracles ascribed to St. Patrick was that of driving the venomous reptiles out of Ireland. Colgan seriously relates that the saint accomplished this feat by beating a drum, which he struck with such fervor that he knocked a hole in it, thereby endangering the success of the miracle, but an angel appearing, mended the drum, and the patched instrument was long exhibited as a holy relic. The Rev. Alban Butler, however, in his "Life of St. Patrick," states as a popular tradition of the Irish, that the miracle was given by his staff, called the "Staff of Jesus," which was kept in great veneration at Dublin.

Ribadeneira, the Jesuit author of "Lives of the Saints," states that no venomous beasts after the miracle could live or breathe in Ireland, "and that even the very wood (of the country) has virtue against poison, so that it is reported of King's College, Cambridge, that being built of Irish wood no spider doth ever come near it."—*Abridged from Land and Water.*

PSYCHOGENESIS IN THE HUMAN INFANT.*

By Professor W. PREYER, of Jena.

WHOEVER would watch the growth of the human mind must first make the soul of the child the object of a methodical investigation. The new-born child in its pitiful helplessness is already an object of extraordinary interest for the psychologist; yet it seems incomprehensible that the progressive unfolding of the senses of the infant—of his will, his reason, his passions, his virtues—has not engaged the attention of any but his relatives. For thousands of years children have been born and lovingly taken care of by their mothers, and for as long a time the learned have contended respecting the growth of their minds without studying the children themselves. The volumes that have been written on the subject without this study are of small use, because they lack the basis of fact. Schoolmasters and tutors can give but little help in the investigation, for the development of the faculties begins long before they are called in to assist it.

The study of the earliest mental growth is useful in its bearing upon the future training of the child. Only certain faculties are innate in every man. A true method of instruction should proceed from the

* Translated from the German by W. H. Larrabee.

given inherited faculties; should take account of their diversities; should not measure all children with the same measure; and should not train them after the same model. It would be desirable in respect to this point if a number of men well versed in physiology should, independently of each other, carefully observe as many infants as possible, and compare results; or if the fathers of children, friends to each other, should mutually exchange observations upon their own children. It would be well for individuals to keep a day-book of the acts of their children from their birth upward. I can say from my own experience that hardly a day passes in the first two years in which something does not occur worthy of notice in its bearing upon mental development. The study must begin with the observation of the sensations and movements of the child. There can be no mental activity without sensation to excite it by giving impressions, and affording a basis for remembrances and comparisons. The sensations are preceded by the movements which begin even before the child is born. The reciprocal action of sensation and movement leads us a step further, to the beginning of the development of the will. As soon as the will becomes effective, the intellect reveals itself, and at last the point is reached when inclination becomes a controlling influence; the feelings assume a real form, and the child begins to communicate its own purposes through speech. The first cry of the new-born child has been regarded by some as an expression of the will, and even as an appeal for relief from pain. This can not be, for a being born without understanding, in the first moment of consciousness, can not be capable of entertaining such purposes as this expression would imply. A more probable theory is that it is the result of a reflex action, like the sounds with which animals respond to a pleasing excitation, as the rubbing of the back, or like the laughter which is provoked by tickling. Frequently the child sneezes instead of crying; and this is a purely reflex action, following an irritation of the nerves of the nose.

The first motions of the limbs of the child give to the unprejudiced observer an impression of aimlessness. The changes in the expression of the face seem to result from what are more like voluntary muscular movements; but when we remember how helpless are the motions of the infant in other respects—that it will be months before it can hold up its head or take hold of any thing, or do any other simple act which seems natural to grown persons—this supposition seems no longer probable. Of what nature, then, are these singular muscular contractions which are never observed again in the whole later life, and the parallels of which are only seen in animals suddenly awakened from their winter slumbers, or occasionally from ordinary sleep? No external cause of disturbance is present to irritate the nerves of motion and the contractile fibers, and so provoke reflex movements. The sleeping infant stirs as the waking one does, only less often and more sluggishly. We can not ascribe the movements at this early period of life to attempts at imitation; the imitative faculty does not begin to be developed till the second half-year. We must look within the child for their cause. An inner cause must be either acquired or inherited. The idea of an acquired cause presupposes varied experiences and observations, of which the child has had none. The inherited causes, then, are the only ones we can consider. It is not enough to say on this point that the child moves as it does because its ancestors did so when they were young. That would only set the problem a step further back. We should rather say that the peculiar movements take place because the central nervous motor organs, when they are fully developed, discharge irregularly the surplus store of motive energy which has been inherited. They have been called instinctive, but instinct comprehends a kind of inherited recollection, and has some definite end, while the motions are aimless. They are impulsive—the direct effect of the nervous energy of the spinal marrow before it has become subject to the restraint of the brain. As the brain is developed, and the intellect manifests itself, the excessive movements are limited, and in persons who have received the most perfect training they are hardly observed at all. They cease when the man has learned to exert the full power of his will over them.

The first manifestation of the will in the child appears when it begins to hold up its head. A chicken can not hold its head up during the first hour after it is hatched; but it can do that, and even pick up a grain of corn, before it can walk or stand firmly. It then begins to run, and learns to do in a day what it takes the human infant a year to accomplish. My attempts to hold a child up straight were not successful for fourteen weeks. Evident voluntary effort began at that time, and after four months the child was able to keep its head well balanced. The lack of power to hold the head up before was not due to want of muscular strength, for the reflex actions, such as that of turning the head, requiring as much power of muscle, were performed firmly enough. Next, after the head, the upper part of the body was balanced. The power to sit up was acquired in about the tenth month, all at once, after the child had been kept up by artificial supports for several weeks. So ability to stand was gained suddenly at the end of the first year, after numerous unsuccessful efforts to stand by the aid of chairs, tables, and the walls of the room. The next acquisition, that of walking, likewise seems to come of itself. Its beginning is obscure, for there appears no occasion in the act of standing for the alternate bendings and stretchings of the legs which enter into it. Similar movements may take place, it is true, when the child is lying down, in its bath or in its cradle, but the regular alternation of them in a standing position is quite different, and is probably, like the act of sucking, derived by inheritance.

It may often be months before the effort to walk is successful, but, if the child is allowed to creep without being interfered with, it will in time begin to walk without instruction. The efforts of walking, standing, and sitting can not be ascribed to any knowledge of the advantage of those actions. They rather arise from the growing power of the will in connection with the muscles and motor nerves, bringing those organs into the modes of action which will prove in later life to be of most advantage to the body, just as has regularly happened to our ancestors. So deeply have the traces of these motive impulses been impressed, so often has the will gone on these nerve-paths and no others, that they are followed at once as soon as the motive impulses of the new-born man are developed. In other words, the efforts are instinctive. The child walks when the inclination to change place is so strong that creeping does not satisfy it, or when it wills to walk, as it sits up or stands when its will to do so is strong enough to command the requisite muscular action. A child observed by me, which could already stand well, all at once, at the end of the fifth quarter-year, for the first time ran around a table, unsteadily, like a drunken man, but without falling. From that day on it went erect, at first hurriedly, then trotting with extended arms, as if to keep from falling, then slower and more firmly. In the course of the next month it went over a door-sill an inch high between two rooms, but holding on to something, and frequently lifting its foot up too high or stamping it down, like one afflicted with a spinal disease. Its will had not yet full control of its muscles, and it could not measure the force of its efforts.

The movements of grasping afford interesting objects of observation. Their development has to be watched with care, for it sometimes takes place at a bound from a lower to a higher degree; at others, proceeds very slowly. A pencil put in the little hand was clasped by the fingers during the first quarter-year; the thumb participated in the action, but not independently—rather as if it were one of the fingers—and the infant did not seem to be aware that it had anything in its hand, holding the object mechanically, as it were. If, at this time, one puts his finger into the child's hand, it will seem to grasp it and hold it, the more so as it keeps a tight hold when the finger is moved back and forth. The action is, however, wholly reflex; there is no intended grasping. The first real effort to take hold of an object was observed in the seventeenth week, when the infant reached after a little India-rubber ball which was near it. When the ball was put into its hand it held it tight for a long time, brought it to its mouth, held it close before its eyes, and looked at it with a peculiar, novel, intelligent expression. On the next day it made many awkward but earnest attempts to take hold of objects of all kinds which were presented before it, fixing its eyes fast upon them, and reaching after things which were too far for it to seize. On the following day, it seemed to give it pleasure to take hold again and again of everything which was within its reach. Wonder was also mingled with its pleasure, and another step was noticed in the development of the infant mind. Toward the end of the fourth month the child raised its arms toward its parents with an indescribable expression of longing. The transition, from grasping after indifferent things so as to take them to itself to reaching after its parents to get nearer to them, was sudden. On the other hand, its own arms and feet appeared to the child for months as something strange, not belonging to it, and it would stare at them and examine them as it did with other objects which engaged its attention. It would take hold of its feet and bring them to its lips ; it would bite its arm even in the fifth quarter-year, so as to cause it to cry out in pain ; it would offer biscuit to its foot to eat, as it did to its wooden horses. There appeared, as yet, no sign of self-consciousness. The unintermitted grasping of objects leads gradually to the comprehension and knowledge of separate existences and the seclusion of self.

Now that the object which has been seen and wished for is touched, a new sensation excites the attention of the child. That which was light or dark, colored or bright, appears to be also smooth or rough, heavy or light, hard or soft, warm or cold, and presents combinations in the same thing appealing to two or three senses. The same apple is red and green, smooth and heavy, cold and hard, and also smells and tastes agreeably. The junction of the sensations of sight, touch, smell, and taste at the same point excites surprise, induces reflection, and arouses the insatiable propensity of the mind to inquire into the causes of its affections. The infant examines the object it is holding, feels of it, and rubs it every way, moves it back and forth, takes it to pieces, and tries to put it together again. With these exercises the will becomes more fully developed. As soon as it is possible to learn the nature of external objects which have affected the senses by examining them, the act of grasping becomes voluntary. Will is developed from the previous desire. The remembrance of the satisfaction which the success of an effort to grasp something has given awakens, at the sight of a new object, the idea of getting hold of it, and with it the impulse to exert the necessary movement. This impulse is called the will. It is still weak in the child, for he lacks self-control, but the obstinacy of early youth shows often enough the force that lies in the unrestrained will.

The sensibility of the skin of a new-born child is very low. We may cause it to cry in the first hour by striking it or by touching it too roughly, but its cries are only reflex actions, not expressions of pain ; on the other hand, we may stick needles into its nose, lips, or hands, without its giving any sign of discomfort, even if so deep a wound is made as to draw blood. I have never tried any experiments of this kind, but I have found that the eyes of new-born children close, when they are touched, more slowly than at a later period and are only imperfectly shut at that, and that they do not close when they are wet in the bath. An increase of sensibility may be perceived in the course of one or two days, especially in relation to temperature. The earliest sensations of temperature are, however, of less immediate psychogenetic significance than those of touch. The hands of the child are the feelers of his soul. Through the excitation of the tactual corpuscles, at the points of the fingers and in the lips, the infant receives the first knowledge of things without him; and through the difference in the sensations arising from the touch of his own skin and that of foreign objects is the foundation laid for self-consciousness on one side and for making experiments on the other. His fingers are, in fact, the instruments with which he endeavors to explore everything that comes within his reach.

Professor Kussmaul has described some important experiments on the sense of taste in infants, in which he found that all new-born children could distinguish strong tastes, and that a very different reaction took place when the tongue was wet with a solution of sugar, from that which followed the application of quinine, vinegar, or salt. Signs of distaste were excited by the three latter substances, and of satisfaction by the sugar, which showed beyond doubt that the power to discriminate tastes begins at birth. The opinion that infants will take alike whatever is offered them holds good if at all, only of substances whose taste is weak. If the child seems displeased at the taste of a strong solution of sugar, as sometimes happens, that is only the effect of the surprise which all new intense sensations occasion. After the first trial, it will want more sugar, and show its satisfaction at getting it. The same is the case with the young of animals, which readily distinguish tastes and seem astonished at new ones; and the newly hatched chicken will at once select the food, where it is given a choice, which is most agreeable to it. Taste is, then, the first sense which affords clear perceptions, and is the first which gives occasion for the exercise of the faculties of memory and judgment.

The sensations of smell can hardly be separated from those of taste. Infants appear able to distinguish odors very early, but to what extent has not been ascertained. They are able to tell one kind of food from another by this means, and have been known to decline the acquaintance of a new nurse whose presence was disagreeable to them. It is known that animals that are born blind are guided to their food—the mother's milk—by this sense. Some odors, as that of tobacco-smoke, have been found to be disagreeable to young animals; others, as that of camphor, pleasant.

All infants are deaf at birth, because the outer ear is as yet closed, and there is no air in the middle ear. A response to a strong sound is observed, at the earliest, in six hours, often not for a day, sometimes not for two or three days. The awakening of the sense may be recognized by means of the drawing up of the arms and the whole body, and the rapid blinking which a loud noise provokes; and it is a sign of deafness if the child, after its ears have had time to come into a suitable condition for hearing, fails to respond thus to a strong sound. No other organ of sense contributes so much to the early spiritual development of the child as that of hearing after it has become fully developed. The superiority of the ear over the eye in regard to this point is shown by the intellectual backwardness of persons who are born deaf as compared with those who are born blind. At the beginning of life, as a rule, the voices of the mother and the nearest relatives afford the first impressions of sound. Very soon these voices are distinguished, and different tones and noises are differently responded to. It is particularly interesting to compare the soothing operation of singing of the cradle melodies with the extraordinary vivacity exhibited on the hearing of dance-music, in the second month. Certain sounds, as those of the consonants *sh*, *st*, and of the male voice, are effective at a very early period in quieting the crying of a child, while other strong and strange ones, like the whistle of an engine, will cause it to cry. Observations on these points, which are easily multiplied, show that, in spite of its original deafness, the child learns very soon to discriminate between the impressions of sound.

The faculty of seeing has a similar growth. Light seems at first unpleasant, and only faint lights are borne; the baby shuts its eyes tight when a candle is brought near them. Brightness and darkness, if they are marked, can be distinguished, but with this the office of the eyes in the earliest days is exhausted. The motions of the eyes are wholly unregulated. One will look to the right, the other to the left; one may be open, the other shut; one will be still while the other moves. Among the numerous combinations of movements both eyes will occasionally move together, but no real symmetry in the muscular contractions can be predicated for the first six days. The first perceptions are evidently only those of the different degrees of strength of light. These attract attention, and some children are said to have turned their heads to the window after the first day. I have noticed it on the sixth day. On about the ninth day most infants begin to stare, into the void, or if a bright object, as a candle, is brought before them, as if they were looking at it; but it is easily found out by trial that there is no real seeing, for it is only when the light is brought directly within its line of vision that the eye is directed toward it. Not for three weeks will the eye which is turned toward a light follow it when it is slowly moved, and then only with a partial motion of the head. But little intelligence is involved in this, for the movements of the eyes and of the head are often in opposite directions. Nevertheless, the face of a month-old child gains an appearance of intelligence when it looks with both eyes upon a slowly moving object and follows its motions; but the stupid expression returns, and does not finally disappear till the second quarter-year. The face grows more human and spirited as the power is gained of regarding objects with a steady, independent look. The faculty of accommodation, or the power of rapidly adapting the eye to the perception of objects at different distances, is then in the process of development, and the unsymmetrical movements of the eyes gradually cease.

The power to distinguish colors follows. One child prefers yellow, another red; all dislike black and dark colors as well as dazzling bright ones. It is hard to decide when the finer degrees of color and their grades of brightness begin to be recognized, for the time differs with the individuals. I do not know of any child that could point out red, green, yellow, blue, correctly on demand before the beginning of the third year.

The recognition of forms proceeds very slowly. Experiments on blind persons, who have had their sight restored by operations, after they had learned to see, show that they could not distinguish curved figures from angular ones by sight alone, nor at all until they had felt of them. The same is doubtless the case with every little child. Numerous observations show how defective is the estimation of distances in early years. The well-known reaching out for the moon is a case in point. Even long use does not give accuracy in the exercise of this power. The same is the case with the perception of magnitudes. A child in its third year will try to put its larger playthings into the boxes designed for little ones, to put pieces of bread into its mouth that are too large for it, and to take hold of large things with its tiny hands. The first sensations of changes in the field of vision, such as are given when a bright object is taken from it, as by the extinction of a lamp, and when a new object is substituted for it, as when the lamp is lighted again, always make a deep impression on the young child. In the first month no notice is taken of the swiftest approach of the hand to the face, and the act of blinking when a threatening movement is made toward the eye is not acquired till the third month. This fact enables us to distinguish between inherited and acquired incidents of sight. The contraction of the pupil in the light and its expansion in the gloom are inherited, and common to all new-born children; the blinking is acquired: it is a precaution against danger, of which the child in its first months knows nothing. By frequent repetitions it becomes habitual, and at last reflexive, like other defensive contractions of the muscles. By the frequent repetition of observations and experiments of the kind described above, it is possible to follow the gradual development of the senses in individuals. But much material must yet be collected before we can clearly set forth the sensual basis of the spiritual growth of the child. The sensations are the material out of which every man makes his world. The emotions of the child, his inclinations and disinclinations, the development of his sense of obligation, the beginning of the formation of his character, the opening of his talents, all depend primarily on the unfolding of his senses. We have so far, on this subject, nothing but an array of facts, with little connection between them.

The study of the growth of the faculty of speech is also of the highest importance in its bearing upon our knowledge of the condition of the child's mind, and of his intellectual operations. I have been in the habit of setting down daily on paper every expression, every sound that could be represented in writing, uttered by a child during the first two years, and am about to publish, on the basis of the facts thus gathered, a special work on the history of the growth of the power of speech. I can give here only a few notes of general interest.

It is extremely hard to exclude the influence of imitation from the child; and, when it is not excluded, to separate what is acquired by it from what is inherited. No one will believe that a child was ever born able to speak, or that he could learn to speak without exercising the power of imitation. Yet it would be wrong to conclude that the faculty of speech is acquired, or is absolutely not inherited. Whatever properties of organisms are constantly repeated periodically are called hereditary; whatever endures through many generations is called inherited. Speech thus endures. It can not be said to be born with the child any more than the teeth and beard are born with him, but the foundation of it, the predisposition to it, is born with the child, the same as are the foundations of those organs. And when a person is prevented from speaking by some defect of his organs of speech, he proves that the faculty still exists within him by the readiness with which he will take up a substitute for speech—writing, or the sign-language. The psychologist can hardly experience a greater intellectual enjoyment than that which is given by observing the development of speech from the first reflexive cry through the thousand and one days of the beginning of human life; at first unintelligible, gradually flowing slowly and interruptedly from unrevealed sources, then gushing lively and irregularly, afterward getting slowly relieved of the non-essentials and becoming more orderly and plain, clearer, and flowing; finally, proceeding in a clear stream of connected language, which testifies to the rule of reason over the natural inclination, the victory of the will, and the formation of thought.

At first only the vowel-sounds are uttered. Even in the first five weeks the tones are so diversified that the condition of the child can be learned from them alone. The periodically broken cry, with knit eyes, denoting hunger; the continuous whine for cold; the high, penetrating tone expressing pain; the laugh over a bright button; the crow of pleasure; the peculiar expression, with motion of the arms, of the wish for a change of position—are easily distinguished utterances, partly reflexive, partly expressive. The prattlings of the infant during the first six months can not be represented on paper, and appear to be significant only of the general muscular movements in which the organs of speech participate, combined with the flowing in and out of the air. I heard the first consonant, *m*, in the seventh week; in the seventh month only *m*, *b*, *d*, *n*, *r*; rarely *g* and *h*, very rarely *k*, could be distinguished in the babblings. Gradually the voice became more steadily modulated. When the child wanted some new thing, besides stretching out its arms and looking at it, it signified its desire by the same sound it had been accustomed to utter when it wanted to be nursed. At the same time the syllables *pa*, *at*, *ta*, *ba*, *da*, *ma*, *na*, common to children of all nations, were uttered plainly and frequently. They had no meaning, and were only the consequences of the involuntary exercises of the vocal apparatus.

Very imperfect imitations of sounds were noticed toward the end of the first six months. The power of distinguishing words when spoken began to appear at about the same time. The baby turned its head when it was called, and it was taught to do such little acts as give its hand when asked to. Still, the store of words it knew was not larger or more comprehensive than that of a well-trained hunting-dog. The enormous intellectual interval between the child and the trained animal was manifested less by its connection of definite objects with certain changes of sound than by its feeble attempts to repeat the syllable or the word when the impression recurred to which they corresponded.

Great progress is made in the imitation of sounds after the third half-year. Numerous objects are correctly pointed out in answer to questions, and many words are spoken with a broken articulation, but in a correct sense. The child's advancement in the power of forming notions becomes wonderfully rapid, and it learns to connect its ideas, to compare and reflect before it has acquired the use of any considerable number of words, and while it still expresses its thoughts by gestures more than by words.

The powers of articulation become well developed at the beginning of the fourth half-year, although the child may still not be able to pronounce all the sounds of his language; but an intelligent child is able to understand many more words than he can repeat, and will also repeat, in a parrot-like way, many words that he does not understand, if they please him or he finds that his speaking them pleases others.

The organs of articulation have a wonderful flexibility, putting it into the power of the child to learn to pronounce the sounds of any language which may be taught him with an ease and accuracy which can never be gained later in life. The child's own language is, however, crude and elementary, consisting in the main of inarticulate sounds, looks, gestures, parts of words that are mangled beyond all recognition, and onomatopoetic expressions. The way he learns to speak is incomprehensible to the keenest observer. He cries, laughs, babbles, smacks, crows, squeals, and understands what is said to him long before he speaks; and after he has touched, looked, listened, and tasted innumerable times, after he has amused himself and got tired with a thousand efforts to imitate, after he has been at first unable to repeat, and often would not repeat words, then he speaks spontaneously. At first he speaks in such a way as to make a single word answer for several whole phrases. Shortly, two, three words are spoken in connection ; then the child is able, in broken phrases, to give an imperfect account of something that has happened. It is not a very long step from these beginnings to the construction of real sentences. The use of the pronouns, verbs, and articles, is attended with difficulties for some months, but the way is broken. The sentence gradually assumes a correct shape, and the child at last gives clear evidence of his intellectual power, more through his shrewd questions than his answers.

If we compare the defects of childish speech with the lapses of grown persons after their faculties have been disturbed by sickness, we shall discover parallels of uncommon interest and astonishing completeness. All the faults of speech caused by sickness have their miniature counterpart in the child. From illness, the matured man is no longer in a condition ; in childhood, the unmatured man is not yet in a condition, to speak correctly. In the former case, existing powers are disturbed ; in the latter the powers of articulation and phrase-making have not been perfected. One condition helps us to understand the other. The parallel can not, however, be pursued here, for the material for illustrating it is rich and will not admit of abridgment. My present purpose has simply been to sketch the fundamental conditions of the earliest development of the infant mind independently of the theories of the day, and to set forth the extraordinary significance of the study.

CLIMBING PLANTS.

By FRANCIS DARWIN, F. L. S.

I THINK most people have a general idea of what a climbing plant is. Even in the smoky air of London two representatives of the class flourish. A certain house in Portman Square shows how well the Virginian creeper will grow ; and the ivy may be seen making a window-screen for some London dining-rooms.

Many other climbing plants will suggest themselves—the vine, the honeysuckle, the hop, the bryony—as forming more or less striking elements in the vegetation.

If we inquire what qualities are common to these otherwise different plants, we find that they all have weak and straggling stems, and that, instead of being forced, like many weakly-built plants, to trail on the ground, they are all enabled to raise themselves high above it, by attaching themselves in some way to neighboring objects. This may be effected in different ways : by clinging to a flat surface, like the ivy; or twining round a stick, like the hop; or making use of tendrils, like the vine.

These various contrivances have been studied by more than one German naturalist, as well as by my father, in whose book on the "Habits of Climbing Plants" very full details upon this subject will be found.

Climbing plants are, first of all, divided roughly into those which twine and those which do not twine; twiners are represented by the hop and the honeysuckle, and all those plants which climb up a stick by winding spirally round it. Those which are not twiners—that is, which do not wind spirally round a stick—are such as support themselves by seizing hold of any neighboring object with various kinds of grasping organs; these may be simple hooks, or adhering roots, or they may be elaborate and sensitive tendrils, which seize hold of a stick with a rapidity more like the action of an animal than of a plant. We shall come back to this second class of climbing plants, and shall then consider their various kinds of seizing organs. I merely wish now to insist on the importance of distinguishing between these two methods of climbing, in one of which the plant ascends a support by traveling spirally round it; in the other, fixes on to the support by seizing it at one place, and continuing to seize it higher and higher up as its stem increases in length.

I have heard the curator of a foreign botanic garden bitterly complain of his gardeners that they never could learn the difference between these two classes of climbing plants, and that they would only give a few bare sticks to some tendril-bearing plant, expecting it to twine up them like a hop, while the plant really wanted a twiggy branch, up which it might creep, seizing a twig with each of its delicate tendrils, as it climbed higher and higher. These two kinds of climbers—twiners and non-twiners—may be seen growing up their appropriate supports in any kitchen-garden where the scarlet-runners twine spirally up tall sticks, while the peas clamber up the bushy branches stuck in rows in the ground.

A hop-plant will supply a good example of the mode of growth of true twining plants. Let us imagine that we have a young hop-plant growing in a pot; we will suppose that it has no stick to twine up, and that its pot stands in some open place where there are no other plants to interfere with it. A long, thin shoot will grow out, and, not being strong enough to support itself in the upright position, will bend over to one side. So far we have not discovered anything remarkable about our hop; it has sent out a straggling shoot, which has behaved as might be expected, by falling over to one side. But now, if we watch the hop-plant closely, a very remarkable thing will be seen to take place. Supposing that we have noticed the shoot, when it began to bend over, pointed toward the window—say a north window—and that, when we next look at it after some hours, it points into the room, that is to say, south, and again, north after another interval, we shall have discovered the curious fact that the hop-plant has a certain power of movement by which its shoot may sometimes point in one direction, sometimes in another. But this is only half the phenomenon, and, if we examine closely, we shall find that the movement is *constant and regular*, the stem first pointing north, then east, then south, then west, in regular succession, so that its tip is constantly traveling round and round like the hand of a watch, making on an average, in warm August weather, one revolution in two hours. Here, then, is a most curious power possessed by the shoots of twining plants, which is worth inquiring further into, both as regards the way in which the movement is produced, and as to how it can be of any service to the plant. Questions are often asked in gardening periodicals as to how hops or other climbing plants always manage to grow precisely in the direction in which they will find a support. This fact has surprised many observers, who have supposed that climbing plants have some occult sense by which they discover the whereabouts of the stick up which they subsequently climb. But there is in reality no kind of mystery in the matter: the growing shoot simply goes swinging round till it meets with a stick, and then it climbs up it. Now, a revolving shoot may be more than two feet long, so that it might be detained in its swinging-round movements by a stick fixed into the ground at a distance of nearly two feet. There would then be a straight bit of stem leading from the roots of the plant, in a straight line to the stick up which it twines, so that an observer who knew nothing of the swinging-round movement might be pardoned for supposing that the plant had in some way perceived the stick and grown straight at it. This same power of swinging round slowly comes into play in the very act of climbing up a stick.

Suppose I take a rope and swing it round my head: that may be taken to represent the revolving of the young hop-shoot. If, now, I allow it to strike against a rod, the end of the rope which projects beyond the rod curls freely round it in a spiral. And this may be taken as a rough representation of what a climbing plant does when it meets a stick placed in its way. That is to say, the part of the shoot which projects beyond the stick continues to curl inward till it comes against the stick; and, as growth goes on, the piece of stem which is projecting is, of course, all the while getting longer and longer; and, as it is continually trying to keep up the swinging-round movement, it manages to curl round the stick. But there is a difference between the rope and the plant in this—that the rope curls round the stick at the same level as that at which it is swung, so that, if it moves round in an horizontal plane at a uniform height above ground, it will curl round the stick at that level, and thus will not climb *up* the stick it strikes against. But the climbing plant, although it may swing round when searching for a stick, at a fairly uniform level, yet, when it curls round a stick, does not retain a uniform distance from the ground, but by winding round like a corkscrew it gets higher and higher at each turn.

One may find a further illustration of the action of twining in the swinging-rope model. It is a peculiarity of twining plants that they can only ascend moderately thin supports. A scarlet-runner can climb up a bit of string, or a thin stick, an inch or two in diameter, but when it comes to anything thicker than this it fails to do so. Just as, when the swinging-rope strikes against a large trunk of a tree, it would be unable to take a turn round it, and would fall to the ground instead of gripping it with a single turn, as it does a thin stick. The difficulty which a climbing plant has in ascending a thick stick will be better understood by going back to the original swinging-round movement which the plant makes in search of a stick, and considering how the movement is produced.

As plants have no muscles, all their movements are produced by unequal growth; that is, by one half of an organ growing in length quicker than the opposite half. Now, the difference between the growth of a twining plant which bends over to one side and an ordinary plant which grows straight up in the air lies in this, that in the upright shoot the growth is nearly equal on all sides at once, whereas the twining plant is always growing much quicker on one side than the other.

It may be shown by means of a simple model how unequal growth can be converted into revolving movement. The stem of a young hop is represented by a flexible rod, of which the lower end is fixed, the upper one being free to move. At first the rod is supposed to be growing vertically upward, but when it begins to twine one side begins to grow quicker than any of the others: suppose the right side to do so, the result will be that the rod will bend over toward the left side. Now, let the region of quickest growth change, and let the left side begin to grow quicker than all the others, then the rod will be forced to bend back over to the other side. Thus, by an alteration of growth, the rod will bend backward and forward from right to left. But now imagine that the growth of the rod on the sides nearest to and farthest from us enters into the combination, and that, after the right side has been growing quickest for a time, the far side takes it up, then the rod will not bend straight back toward the right, as it did before, but will bend to the near side. Now the old movement, caused by the left side growing quickest, will come in again, to be followed by the near side growing quickest. Thus by a regular succession of growth on all the sides, one after another, the swinging-round movement is produced, and by a continuation of this action, as I have explained, the twining movement is produced.

I have spoken as if the question of how plants twine were a completely solved problem, and in a certain sense it is so. I think that the explanation which I have given will remain as the fundamental statement of the case. But there is still much to be made out. We do not in the least know why every single hop-plant in a field twines like a left-handed screw, while every single plant in a row of beans twines the other way; nor why in some rare instances a species is divided, like the human race, into right- and left-handed individuals, some twining like a left-handed, others like a right-handed screw. Or, again, why some very few plants will twine half-way up a stick in one direction, and then reverse the spiral and wind the other way. Nor, though we know that in all these plants the twining is caused by the change in the region of quickest growth, have we any idea what causes this change of growth. There is still much to work at, and it is to be hoped that there are still plenty of workers to solve the problems. It is by looking to exceptions that the key to a problem is often found. It is the exceptions to general rules that often lead us to understand the meaning and origin of the rules themselves; and it is to such exceptions that any one who wants to work at climbing plants should turn. Now, it is a general rule that a climbing plant twines in the same way that it revolves. It seems an obvious thing that in the case of the rope model, if we swing the rope round our head in the direction of the hands of a watch, it must twine round the stick against which it strikes in the same direction. But in plants it is not always so. In the large majority of cases it is so, for, if this were not the case, the illustration of the rope would not have been applicable; but it is not universally the rule. Every individual of the plant *Hibbertia* always twines round its stick in the same direction, but, when it is performing the swinging movement in search of a support, it is found that some plants travel round with the sun, others in the opposite direction. This fact forms an exception of a striking kind—and such exceptions are worthy of close study.

There are other facts of a different nature, which seem to show how difficult the problem is, and how delicately balanced is that part of the organization of the plant which is connected with the power of climbing. For instance, if we cut a branch of most shrubs, and put it in water, it goes on growing, apparently as healthily as ever. Indeed, the practice of making cuttings—where a cut-off branch or shoot develops roots and turns into a new plant—shows us that no serious injury is thus caused. But the twining organization is sensitive to such treatment. A cut branch of hop placed in water was observed to make its revolutions in about twenty hours, whereas in its natural condition—growing on the plant—it makes a complete turn in two or three hours. Again, if a plant growing in a pot is moved from one greenhouse to another, the slight shaking thus caused is sufficient to stop the revolving movement for a time—another proof of the delicacy of the internal machinery of the plant.

Some of the problems, as, for instance, why twining plants can not as a rule climb thick stems, may be looked at from the natural-history point of view. Most of our climbing plants die down in the winter, so that, if they were able to climb round big tree-trunks, they would waste all the precious summer weather in climbing a few feet, whereas the same amount of longitudinal growth devoted to twining up a thin stick would have raised them up to the light after which they are striving. And as a plant exercises no choice, but merely swings round till it hits against an object, up which it will then try to twine, it seems as if the inability to climb thick stems might be a positive advantage to a plant, by forcing it to twine up such objects as would best repay the trouble.

In the classification of climbing plants, proposed by my father in his book, he makes a subdivision of "hook-climbers." These may be taken as the simplest representatives of that class of climbers which are not twining plants. The common bramble climbs or scrambles up through thick underwood, being assisted by the recurved spines which allow the rapidly growing shoot to creep upward as it lengthens, but prevent it from slipping backward again; the common goose-grass (*Galium*) also climbs in this way, sticking like a burr to the side of a hedge-row up which it climbs. Most country boys will remember having taken advantage of this burr-like quality of *Galium* in making sham birds'-nests, the prickly stems adhering together in the desired form. Such plants as the bramble or *Galium* exhibit none* of the swinging-round movement which I have described in twiners: they simply grow straight on, trusting to their hooks to retain the position gained.

In some species of clematis we find a mechanism which reminds one of a simple hook-climber, but is in reality a much better arrangement. The young leaves projecting outward and slightly backward from the stem may remind us of the hooked spines of a bramble, and like them easily catch on neighboring objects, and support the trailing stem. Or the leaf of the species of clematis given in Fig. 1 may serve as an example of a leaf acting like a hook. The main stalk of the leaf is seen to be bent angularly downward at the points where each successive pair of leaflets is attached, and the leaflet at the end of the leaf is bent down at right angles, and thus forms a grappling apparatus. The clematis does not, like the bramble, trust to mere growth, to thrust itself among tangled bushes, but possesses the same powers of revolving in search of a support which simple or true twining plants possess. Indeed, many species of clematis are actually twining plants, and can wind spirally up a stick placed in their way. And the same revolving movement which enables them thus to wind spirally also helps them to search for some holding-place for their hook- or grapple-like leaves, and in many species the search is carried on by the leaves swinging round, quite independently of the revolving movement of the stem on which they are borne.

* That is to say, the revolving movement is not sufficiently developed to be of practical importance. The same remark is applicable to the other cases in which I have spoken of the absence of revolving movement in the growing parts of plants.

If a leaf of a clematis succeed by any means in hooking on to a neighboring object, the special characteristic of leaf-climbing plants comes into play. The stalk of the leaf curls strongly over toward the object touching it, and clasps it firmly. It is obvious how great is the advantage thus gained over a mere hook. A leaf such as that shown

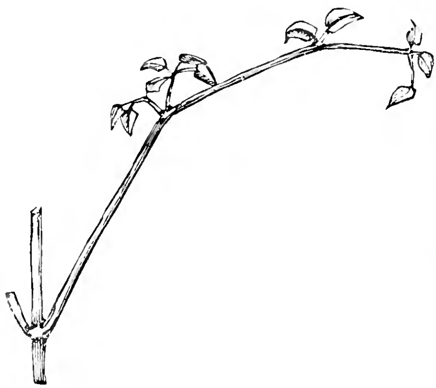


FIG. 1.*—A YOUNG LEAF OF CLEMATIS VITICELLA.

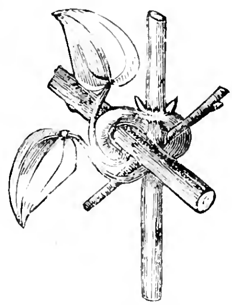


FIG. 2.—CLEMATIS GLANDULOSA, With two young leaves clasping two twigs, with the clasping portions thickened.

in Fig. 2 might be made to catch on to a neighboring twig by its bent stalk, in such a way that, although it managed to stay where it was, it could bear none of the weight of the plant, and would be liable to be displaced by a strong wind or other disturbance. But, when the stalk of the leaf had curled close round the twig, nothing could displace it, and it could take its share in the work of supporting the plant.

The extreme sensitiveness of the leaf-stalk to slight and gentle touches gives a curious idea of the alertness of the plant in its search for supporting objects. A leaf may be excited to bend by a loop of string weighing only one-sixteenth of a grain. It is an interesting fact that, in such a hook-like leaf as that of *Clematis viticella* (Fig. 1), the hooked end of the leaf, which has the best chance of coming into contact with obstacles, is the most sensitive part. This has been made out by hanging small weights on different parts of the leaf, and it is found that the terminal leaflet bends in a few hours after a loop of string weighing less than a grain is hung on it, and which produced no effect in twenty-four hours on the other petioles. One may see proof of the sensitiveness of the leaf-stalks of the wild English clematis, which sometimes catches withered leaves or delicate stalks of the quaking-grass. The same thing is shown by a leaf after having been touched with a little water-color, the delicate crust of dry paint being mistaken for something touching the plant. In such cases, or when the leaf has been merely rubbed with a twig, which is taken away before the leaf seizes

* For the loan of this and the other woodcuts illustrating this article, we are indebted to the kindness of Mr. Charles Darwin and Mr. Murray.

it, the plant discovers that it has been deceived, and, after bending for a time, it unbends and becomes straight again.

The bending, which enables a leaf to seize a twig, is not the only change which the stimulus of a touch produces. The leaf-stalk swells and becomes thicker and more woody, and turns into a strong, permanent support to the plant. The thickening of the leaf-stalks is to be made out in Fig. 2, which represents a shoot of clematis, bearing two leaves, each of which has seized a twig; in one of the leaf-stalks this thickening has commenced, and is fairly evident. The thickened and woody leaf-stalks remain in winter after the leafy part has dropped off, and in this condition they are strikingly like real tendrils.

The genus *Tropæolum*, whose cultivated species are often called nasturtiums, also consists of leaf-climbing plants, which climb like clematis by grasping neighboring objects with their leaf-stalks.

In some species of *Tropæolum* we find climbing organs developed, which can not logically be distinguished from tendrils; they consist of little filaments, not green like a leaf, but colored like the stem. Their tips are a little flattened and furrowed, but never develop into leaves; and these filaments are sensitive to a touch, and bend toward a touching object, which they clasp securely. Filaments of this kind are borne by the young plant, but it subsequently produces filaments with slightly enlarged ends, then with rudimentary or dwarfed leaves, and finally with full-sized leaves; when these are developed they clasp with their leaf-stalks, and then the first-formed filaments wither and die off; thus the plant, which in its youth was a tendril-climber, gradually develops into a true leaf-climber. During the transition, every gradation between a leaf and a tendril may be seen on the same plant.

Fig. 3.—Bignonia. An unnamed species from Kew.

It is not always the stalk of a leaf which is developed into the clasping organ; the bignonia-leaf shown in Fig. 3 bears tendrils at its free extremity. And in other plants tendrils are formed from flower-stalks, in which the flowers are not developed, or the whole stem of the plant or a single branch may turn into a tendril. In one curious case of monstrosity, what should have been a prickle on a sort of cucumber, grew out into a long, curled tendril.

The family of the *Bignonias* is one of the most interesting of the class of tendril-climbers, on account of the variety of adaptation which is found among them.

In the above-mentioned Fig. 3 is seen the tendril-bearing leaf of a species of *Bignonia*. The leaf bears a pair of leaflets, and ends in a tendril having three branches. The main tendril may be compared to a bird's leg with three toes, each bearing a small claw. And this comparison seems apt enough, for, when the tendril comes against a twig, the three toes curl round it like those of a perching bird.

Besides the toes or tendrils, the leaf-stalk is sensitive, and acts like that of a regular leaf-climber, wrapping itself round a neighboring object.

In some cases the young leaves have no tendrils at their tips, but clasp with their stalks, and this is a case exactly the reverse of *Tropæolum*—a tendril-chamber whose young leaves have no tendrils, instead of a leaf-climber whose young climbing organs are not leaves. Thus the close relationship that exists between leaf- and tendril-climbers is again illustrated.

This plant also combines the qualities of another class of climbers, namely, twiners, for it can wind spirally round a support as well as a hop or any other true twiner. Another species (*B. Tweedyana*) also helps to support itself by putting out roots from its stems, which adhere to the stick up which the plant is climbing. So that here are four different methods of climbing—twining, leaf, tendril, and root climbing—which are usually characteristic of different classes of climbing plants, combined in a single species.

Among the *Bignonias* are found tendrils with various curious kinds of sensitiveness. The tendrils of one species exhibit, in the highest perfection, the power of growing away from light toward darkness, just the opposite to the habit of most plants. A plant, growing in a pot, was placed so that the light came in on one side. One tendril was pointing away from the light, to begin with, and this did not move ; but the opposite tendril, which was pointing toward the light, bent right over and became parallel to the first tendril. The pot was then turned round, so that both pointed toward the light, and they both moved over to the other side, and pointed away from the light. In another case, in which a plant, with six tendrils, was placed in a box, open at one side, all six tendrils pointed like so many weathercocks in the wind—all truly toward the darkest corner of the box. These tendrils also showed a curious power of choice. When it was found that they preferred darkness to light, it was tried whether they would seize a blackened glass tube, or a blackened zinc plate. The tendrils curled round both these objects, but soon recoiled and unwound with what, my father says, he can only describe as disgust. A post with very rugged bark was then put near them ; twice they touched it for an hour or two, and twice they withdrew ; but at last one of the hooked tendrils caught hold of a little projecting point of bark ; and now it had found what it wanted. The other branches of the tendril quickly followed it, spreading out, adapting themselves to all the inequalities of the surface, and creeping into all the little crevices and holes in the bark. Finally a remarkable change took place in the tendrils : the tips which had crept into the cracks swelled up into little knobs, and ultimately secreted a sticky cement, by which they were firmly glued into their places. This plan of forming adhesive disks on its tendrils is one which we shall find used by the Virginia creeper, as its only method of support, and it forms the fifth means of climbing to be met with among the *Bignonias.* We see now the meaning of the power possessed by the tendrils of moving toward the dark, for in this way they are enabled to find out and reach the trunks of trees to which they then become attached. It seems, moreover, that the tendrils are especially adapted to the moss- or lichen-covered trees, for the tendrils are much excited by wool, flax, or moss, the fibers of which they can seize in little bundles. The swelling process is so delicate that, when two or three fine fibers rest on the end of a tendril, the swelling occurs in crests, thinner than a hair, which insert themselves between and finally envelop the fibers. This goes on so that the ball at the end of a tendril may have as many as fifty or sixty fibers imbedded in it, crossing each other in different directions.

The tendrils of the Virginia creeper may here be worth noticing. This plant can climb up a flat wall, and is not adapted to seize sticks or twigs ; its tendrils do occasionally curl round a stick, but they often let go again. They, like bignonia-tendrils, are sensitive to the light, and grow away from it, and thus easily find out where the wall lies up which they have to climb. A tendril which has come against the wall is often seen to rise and come down afresh, as if not satisfied with its first position. In a few days after a tendril has touched a wall the tip swells up, becomes red, and forms one of the little feet or sticky cushions by which the tendrils adhere, and which are shown in Fig. 5. The adherence is caused by a resinous cement secreted by the cushions, and which forms a strong bond of union between the wall and the tendril. After the tendril has become attached it becomes woody, and is in this state remarkably durable, and may remain firmly attached and quite strong, for as many as fifteen years.

Besides this sense of touch, by which a bignonia-tendril distinguishes between the objects which it touches, there are other instances of much more perfect and incomprehensible sensibility. Thus some tendrils, which are so sensitive that they curl up when a weight of one-thirtieth or even one-fiftieth of a grain is placed on them, do not take the least notice of a shower of rain whose falling drops must cause a much greater shock to the tendrils.

Again, some tendrils seem to have the power of distinguishing between objects which they wish to seize and their brother tendrils which they do not wish to catch. A tendril may be drawn repeatedly over another without causing the latter to contract.

The tendrils of another excellent climber (*Cobæa scandens*) possess some curious properties. The tendrils are much divided, and end in delicate branchlets, as thin as bristles, and very flexible, each bearing a minute double hook at its tip. These are formed of a hard, woody substance, and are as sharp as needles ; a single tendril may bear between ninety and a hundred of these beautiful little grappling-hooks.

The flexibility of the tendrils is of service in allowing them to be blown about by a breath of wind, and they can thus be made to seize hold of objects which are out of reach of the ordinary revolving movements. Many tendrils can only seize a stick by curling round it, and this even in the most sensitive tendril must take a minute or two; but with *Cobæa* the sharp hooks catch hold of little irregularities on the bark the moment the tendril comes into contact with it, and afterward the tendril can curl round and make the attachment permanent. The importance of this power of temporary attachment is shown by placing a glass rod near a cobæa-plant. Under these conditions the tendrils always fail to get hold of the glass, on which its grapple-like hooks can not seize.

The movement of the little hook-bearing branches is very remarkable in this species. If a tendril catches an object with one or two hooks, it is not contented, but tries to attach the rest of them in the same way. Now, many of the branches will chance to be so placed that their hooks do not naturally catch, either because they come laterally, or with their blunt backs against the wood, but after a short time, by a process of twisting and adjusting, each little hook becomes turned, so that its sharp point can get a hold on the wood.

The sharp hook on the tendrils of *Cobæa* is only a very perfect form of the bluntly curved tip which many tendrils possess, and which serves the same purpose of temporarily holding the object caught until the tendril can curl over and make it secure. There is a curious proof of the usefulness of even this blunt hook in the fact that the tendril is only sensitive to a touch on the inside of the hook. The tendril, when it comes against a twig, always slips up it till the hook catches on it, so that it would be of no use to be sensitive on the convex side. Some

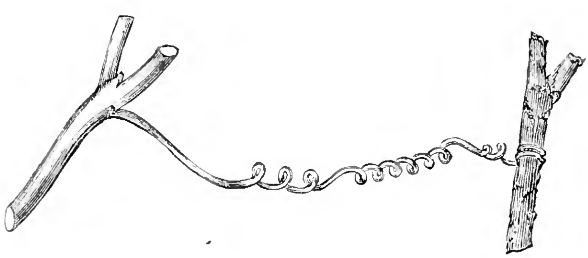


Fig. 4.—A caught tendril of *Bryonia dioica*, spirally contracted in reversed directions.

tendrils, on the other hand, have no hook at the end, and here the tendrils are sensitive to a touch on any side. These tendrils led my father at first into a curious mistake, which he mentions in his book. He pinched a tendril gently in his fingers, and, finding that it did not move, concluded it was not sensitive. But the fact was that the tendril, being touched on two sides at once, did not know which stimulus to obey, and therefore remained motionless. It was in reality extremely sensitive to a touch on any one of its sides.

There is a remarkable movement which occurs in tendrils after they have caught an object, and which renders a tendril a better climbing organ than any sensitive leaf. This movement is called the "spiral contraction," and is shown in Fig. 4, which represents the spirally contracted tendril of the wild bryony; it may also be seen in Fig. 5, which represents the tendrils of the Virginia creeper. When a tendril first seizes

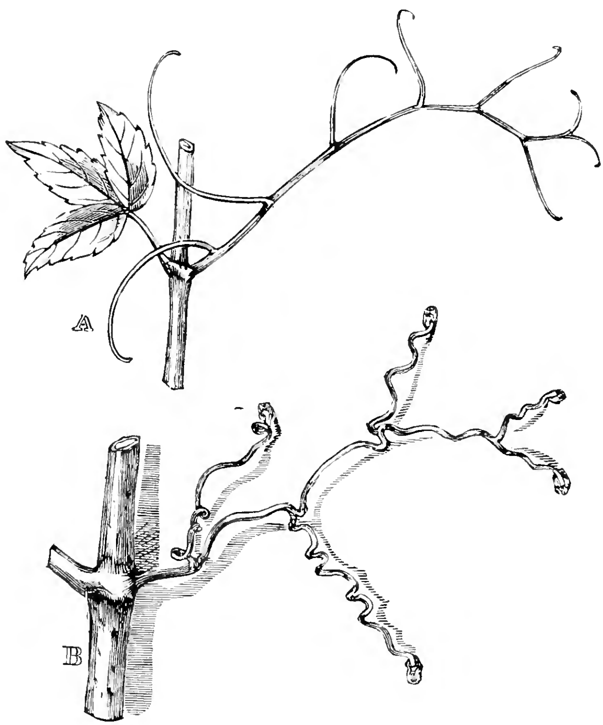


FIG. 5.—AMPELOPSIS HEDERARIA. A. Tendril fully developed, with a young leaf on the opposite side of the stem. B. Older tendril, several weeks after its attachment to a wall, with the branches thickened and spirally contracted, and with the extremities developed into disks. The unattached branches of this tendril have withered and dropped off.

an object it is quite straight, with the exception of the extreme tip, which is firmly curled round the object seized. But in a day or two the tendril begins to contract, and ultimately assumes the corkscrew-like form represented in the figures. It is clear that in spirally contracting the tendril has become considerably shorter; and, since the end of the tendril is fixed to a branch, it is obvious that the stem of the bryony must be dragged nearer to the object which its tendril has caught. Thus, if a shoot of bryony seizes a support above it, the contraction of the tendril will pull up the shoot in the right direction. So that in this respect the power of spiral contraction gives a tendril-climber an advantage over leaf-climbers which have no contracting power, and therefore no means of hauling themselves up to supporting objects.

But the spiral contraction of tendrils has another use, and this is probably the most important one. This use depends on the fact that a contracted tendril acts like a spiral spring, and is thus converted into a yielding, instead of an unyielding, body. The spirally-wound tendril yields like an elastic thread to a pull which would break the tendril in its original condition. The meaning of this arrangement is to enable the plant to weather a gale which would tear it from its support by snapping the tendrils, if they were not converted into spiral springs.

My father describes how he went in a gale of wind to watch the bryony on an exposed hedge, and how, in spite of the violent wind which tossed the branches of the plant about, the bryony safely rode out the gale, "like a ship with two anchors down, and with a long range of cable ahead, to serve as a spring as she surges to the storm." It may also serve to divide the weight which has to be supported equally among a number of tendrils; and this is the meaning of the spiral contraction seen in the tendrils of the Virginia creeper.

It can be seen in Fig. 4 that all the coils of the spiral are not in the same direction. First, there are two in one direction, then six in the other, and then three again in the first direction, making six turns in one way and five in the other. And this is universally the case; the turns in one direction are always approximately equal in number to those in the opposite direction. It can be shown to be a mechanical necessity that a tendril which has its two ends fixed, and which then coils into a spiral, should behave in this way.

A simple model made to show this mechanical necessity is described by Sachs in his "Text-book." It is made by stretching a strip of India-rubber and cementing it to an unstretched strip. The strips being united in a state of longitudinal strain, form a spiral when released. If the model is held by one end only, the turns of the spiral are all in one direction. And this represents the behavior of a tendril which has not managed to seize a support; for some unknown reason such tendrils contract into spirals, and the turns of such spirals are all in one direction. But, if the India-rubber is held at both ends, half the turns are in one direction, half in the other, just as with a tendril the same thing happens.

Now, let us consider the general relations that exist between twining plants, leaf-climbing plants, and tendril-climbing plants. To an evolutionist the question how these various classes of climbing plants have been developed is perhaps of most interest. What is the relationship between them? Have all classes been developed separately from ordinary non-climbing plants, or has one class been developed out of one of the others; and, if so, which is the oldest form of climbing plant?

There can be little doubt on this latter point. I think we may certainly say that the earliest form which existed was a twining plant. We see that twining plants do not possess the essential feature of leaf- or tendril-bearers, namely, the sensitiveness to a touch which enables a leaf or tendril to grasp a stick. But, on the other hand, most leaf- and tendril-climbers do possess the essential quality of a twiner—the power of revolving or swinging round, which exists in the shoots, leaves, or tendrils of so many of them. This power of revolving merely serves in some leaf- and tendril-climbers to carry on the search for supports; but other leaf- and tendril-climbers, as we have seen, do actually wind spirally round a stick exactly like a true twiner. How twiners originally obtained their power of swinging round we need not now inquire; it seems to be merely an increase of a similar movement which is found to occur in a meaningless manner in other plants. Thus several flower-stems have been observed bowing themselves over and swinging round in small circles, like climbing plants. Here the movement is merely an unintelligible concomitant of growth, for, as we see, the movement is of no advantage to the flower-stem. But the existence of this movement is of great interest to us, for it shows how a twining plant might be developed by a similar movement being found to be advantageous, and being increased by natural selection to the requisite extent.

Another question which may occur to us is this: In what way is climbing by leaves or tendrils a more perfect method than twining? Why, when a plant had become a twining plant, did it not rest satisfied? The fact that leaf- and tendril-climbers have been developed out of twiners, and not *vice versa*, is a proof that climbing by leaves or tendrils is a more advantageous habit than twining; but we do not see why it should be so. If we inquire why *any* plant has become a climber, we shall see the reason. Light is a necessity for all green plants; and a plant which can climb is enabled to escape from the shadow of other plants with a far less waste of material than a forest-tree, which only pushes its branches into the light by sheer growth. Thus the weak, straggling stem of a climbing plant gets all the advantages gained by the solid, column-like tree-trunk. If we apply this test—which is the most economical plan of climbing, twining, or leaf-climbing—we see at once that a plant which climbs by seizing wastes far less material than one which twines. Thus a kidney-bean, which had climbed up a stick to a height of two feet, when unwound from its support was found to be three feet in length, whereas a pea which had climbed up two feet by its tendrils was hardly longer than the height reached. Thus the bean had wasted considerably more material by its method of climbing by twining round a stick, instead of going straight up, supported by its tendrils, like the pea. There are several other ways in which climbing by tendrils is a much better plan than twining. It is a safer method, as any one may convince himself by comparing the security of a tendril-bearer in a heavy wind with the ease with which a twiner is partly blown from its support. Again, by looking at those leaf-climbing plants which still possess in addition the power of twining, it will be seen how incomparably better they grasp a stick than does a simple twiner. And again, a twiner from being best fitted to climb bare stems often has to start in the shade, whereas a leaf- or tendril-climber can ramble for the whole extent of its growth up the sunny side of a bush.

We can thus see plainly how it has been an advantage for twining plants to develop into leaf-climbers. We shall also find reasons why a leaf-climber should find it advantageous to become a tendril-climber.

We have seen how tendrils form a more sensitive, efficient grasping organ than simple leaves. Tendrils possess also the valuable power of shortening themselves by spirally contracting, and thus pulling up after them the stem on which they grow, and afterward serving as springs and breaking the force of the wind. We have had some cases where we see the close relationship between leaf- and tendril-climbers, and where we can see intermediate stages in the process of transition from one method of climbing to the other.

In certain kinds of *Fumaria* we can follow the whole process. Thus we have one kind, which is a pure leaf-climber, grasping by its leaf-stalks, which bear leaflets not at all reduced in size. A second genus has the end leaflets very much smaller than the rest. A third kind has the leaflets reduced to microscopical dimensions; and, lastly, a fourth kind has true and perfect tendrils. If we could see the ancestors of this last kind we should undoubtedly have a series of forms connecting it with an extinct leaf-climber, resembling the series which at present connects it with its contemporary leaf-climbing relatives.

To repeat once more the steps which it is believed have occurred in the evolution of climbing-plants: It is probable that plants have become twiners by exaggerating a swinging-round or revolving movement, which occurred in a rudimentary form, and in a useless condition, in some of their ancestors. This movement has been utilized for twining, the stimulus which has driven the process of change in this direction having been the necessity for light.

The second stage has been the development of sensitive leaves by a twining plant. No doubt at first no leaf-climber depended entirely on its leaves—it was merely a twiner which helped itself by its leaves. Gradually the leaves became more perfect, and then the plant could leave off the wasteful plan of growing spirally up a stick, and adopt the more economical and more effective one of pure leaf-climbing.

Finally, from sensitive leaves were developed the marvelously perfect tendrils which can perceive one fiftieth of a grain, and can show distinct curvature within twenty-five seconds after being touched, tendrils, with delicate, sticky ends, or endowed with the power of moving toward the dark, or of creeping into little cracks, or with that mysterious sense of touch by which a tendril can distinguish a brother tendril from an ordinary twig, and can distinguish the weight of a drop of rain hanging to it from a bit of thread—in short, all the delicate contrivances which place tendril-bearers so eminently at the head of the climbing plants.

There is only one more fact connected with the evolution of climbing plants which must be alluded to, namely, the curious way in which the representatives of the class are scattered throughout the vegetable kingdom. Lindley divided flowering plants into fifty-nine classes, called Alliances, and in no less than thirty-five of these climbing plants are found. This fact shows two things: First, how strong has been the motive power—the search after light—which has driven so many distinct kind of plants to become climbers; secondly, that the power of revolving, which is the first step in the ladder of development of the power of climbing, is present in an undeveloped state in almost every plant in the vegetable series.—*Popular Science Review.*

ÆSTHETIC FEELING IN BIRDS.

By Professor GRANT ALLEN.

THERE is no portion of Mr. Darwin's great superstructure which has been subjected to more searching criticism than his theory of sexual selection—the theory that beauty in animals is dependent, in part at least, upon the choice of brightly colored, ornamented, or musically endowed mates by one or other sex among all the more highly developed classes, such as insects, crustaceans, birds, and mammals. Not only have opponents argued strongly against the existence of such æsthetic tastes in the lower animals as would account for the supposed preference for beautiful partners, but even many of those who accept the evolutionist hypothesis as a whole have declared themselves unable to give in their adhesion to this particular speculation. Professor Mivart has brought forward strong objections to the great naturalist's view, and Mr. A. R. Wallace has raised a counter-theory on the subject of coloration at least, which has done much to convince many wavering biologists, and to insure their rejection of the suggested cause as adequate for the production of that beauty which all alike recognize in the animal world. It seems to me, however, that a little too much stress has been laid upon the notion that comparatively advanced intelligence is necessary for the appreciation of beauty in the opposite sex. It is true that our own highly complex æsthetic feelings are largely composed of elevated intellectual and emotional elements; but it may perhaps be shown that æsthetic tastes quite sufficient for the production of the known results do actually exist in many cases, and consist almost entirely of very simple sensuous factors. In order for a butterfly or a humming-bird to admire its gorgeously appareled mate, it is not necessary that it should be capable of taking delight, like ourselves, in a Claude or a Rubens; it is enough that it should possess a nervous organization pleasurably affected by certain forms and colors in the same way as it is pleasurably affected by sweet fruits or the nectar of flowers. Nothing more than this need be postulated in order to establish the facts for which Mr. Darwin has contended with such wealth of illustration in the second part of the "Descent of Man."

It may be worth while, then, to examine a single large class of animals, in which the æsthetic nature is highly developed, for the purpose of discovering whether they do really afford proof of a sensibility to form, color, or musical sound. It must be remembered that even in our own race the sense of beauty in children, savages, and the uncultured classes, hardly rises above this simple level. We must not, of course, expect to find an appreciation of musical harmony, of imitative pictorial skill, of elaborate ornamentation, among birds or insects. We must be content if we see evidence of a love for red, blue, and yellow, for sweet perfumes and pleasant flavors, for symmetrical forms and simple patterns, for ringing notes and trilled resonances. The class of birds probably shows external marks of such tastes in a higher degree than any other; and, though many of them have been set forth by various writers elsewhere, it will perhaps repay the trouble to collect them into a single paper in order to show their bearing upon the general æsthetic sensibility of the class, as well as upon the specific question of sexual selection. For this purpose I shall first take for granted the fact of such selection, and afterward endeavor to justify it by analogy from known human practice.

Beginning with the lowest of the special senses, taste, we find ample evidence that very many birds have a strong liking for sugar. In confinement, canaries and parrots eagerly devour it in the manufactured form. In the wild state humming-birds, sun-birds, honey-suckers, lories, and many other species, feed off the nectar of flowers, more or less mixed with insects. Mr. Webber, an American naturalist, found that the ruby-throats of the United States were attracted by a cup of sirup, and numerous other birds display a strong liking for the same mixture. Fruits, which have been developed especially to suit the tastes of birds, almost always contain an abundance of sugary juices; while the kernels within their stones are generally bitter, so as to prevent their winged allies from devouring the actual seed. Hence we may infer that all the vast tribes of toucans, hornbills, macaws, plantain-eaters, birds-of-paradise, and fruit-pigeons, possess a taste for sugar sufficiently strong to have produced the separate evolution of these sweet seed-coverings in a hundred different families of plants throughout the whole world. Indeed, the strength of the evidence thus afforded can not be overrated, when we remember that in every case the covering is a dead loss to the plant, except in so far as it aids the dispersion of seeds; and that it must have been developed over and over again in a thousand different cases by the action of the most widely different birds. It is impossible to believe that such a coincidence can be due to accident, impossible to doubt that it results from a genuine taste for sweet flavors.

There is even some reason to believe that birds care for and discriminate other tastes besides the fundamental distinctions of sweet and bitter. All the small birds in Jamaica are particularly fond of the little scarlet capsicums grown in gardens, and devour them so greedily, that the fruit has acquired the common name of *bird-peppers*. If we remember how very hard is often the almost horny covering of a bird's tongue, there is nothing remarkable in the fact that the pungency of the capsicum should be felt as an agreeable stimulant, probably having effects analogous to those of mustard, water-cress, or peppermint, with human beings. The oft-quoted liking of tropical pigeons for the nutmeg, with its aromatic coating of mace, points in the same direction. Parrots in captivity frequently display very decided preferences and antipathies in their food. Owls can not be induced to taste meat in the slightest degree tainted. Again, all birds have a most accurate notion of the difference between ripe fruits and the unripe sour ones, besides carefully choosing the sunny side of peaches, pears, and apricots. The very frequency of distinct sapid principles in fruits would seem to favor the same supposition, as they have probably been acquired for the special allurement of particular species. Indeed, the more we consider the origin and nature of succulent fruits, the more does it become clear that they have been developed to suit the tastes of animals having essentially identical sensations with our own.

The case of the nutmeg leads us naturally on to the consideration of smell. Here we may conclude with great probability that the large class of aromatic fruits has acquired its perfume for the sake of attracting birds, especially when we recollect that flowers have acquired exactly similar perfumes for the sake of attracting insects. And although the possession of scent as a means of sexual allurement is rare among birds, being probably confined to the musk-duck and a few other species, yet it occurs frequently among butterflies, and is represented among mammals by the musk-deer, beaver, and many other ruminants or rodents. Curiously enough, the similarity of taste thus testified extends to the vegetal world in the case of the musk-plant; while even certain carnivores, such as the cat tribe, are extremely fond of "valerian, lemon-thyme, camomile, lavender, and many plants rich in essential oils." On the other hand, a good observer notes that cats have their dislikes, and he has often seen a tabby "smell at a fig-tree, and turn away with the disgusted air of a connoisseur." We have no such strong facts in the case of birds, but the frequency of perfumes in those fruits which depend upon them for the dispersion of their seeds, coupled with their total absence among most nuts, would lead to the conclusion that their likes and dislikes in the matter of smell are fully as marked.

But it is when we arrive at the sense of hearing that we come to the point where proper æsthetic feelings begin. It is quite impossible to doubt that birds are fond of musical sounds. The song of our own nightingales and linnets, the deep notes of the South American bell-bird, the incessant cooing of the dove, the noisy chattering of the parrots, the ringing cry of the whippoorwill, all lead to the same conclusion. Here, again, these sounds are of precisely the same nature as those employed by the crickets, katydids, cicadas, and other musical insects, as well as by man himself in his vocal and instrumental music. Something of the same taste is displayed among the quadrumana by the howlers and other monkeys. But it is a noteworthy fact that ' large majority of these presumably sexual calls, in birds, insects, and other animals, are true musical sounds, not mere noises. I have pointed out elsewhere the probable reason for this preference of pure tones in the case of mankind; and the same argument will apply, *mutatis mutandis*, to all other animals. But there is certainly a singular analogy in this respect between sounds and colors, most animals preferring the relatively pure and simple musical tones to confused noises; and the relatively pure and simple analytic colors, red, blue, green, and yellow, to confused mixtures such as brown, gray, and mud-color. At any rate, a bird evidently pays far more attention to the musical class of auditory perceptions than to mere noise. A canary will take no notice of ordinary confused sounds in a room; but, if one begins to chirp or whistle to it, it immediately responds with another chirp in emulation. So, too, when a piano or other musical instrument is played in the neighborhood of a singing bird, it will often show its recognition of the musical character by pouring out its very fullest flood of song, as if to conquer its unconscious rival. Of course, the singing-matches between birds themselves are too familiarly known to call for separate mention. It may be worth while, however, to notice that this love of musical sound exists even among certain reptiles; for I have often seen the common house-lizard of Jamaica listening with evident interest and attention to the playing of a piano, turning his head from side to side, and scampering away when disturbed, only to return again to the fascinating sound after a minute or two of hesitation.

The cases of the starling, the piping bullfinch, and the mocking-bird, which can be taught to whistle a tune, show the same power still more highly developed. These instances prove not merely susceptibility to musical sounds, but also a capacity for distinguishing the harmonic intervals. It is stated that some birds, even in the wild state, display considerable knowledge of the musical scale; and a San Francisco naturalist is at present engaged upon a work in which he hopes to show that the human ear possesses in this respect merely a more highly developed form of the common vertebrate sensibility. When we reflect upon the purely physical and physiological basis which, as Helmholtz has taught us, underlies the musical intervals and the distinctions of harmony and discord, there is certainly no reason why they should not be perceived by all the higher animals alike, in a greater or less degree.

Considering, therefore, the evident susceptibility of birds to the simpler pleasures of music, and the interest which they show in it even apart from their domestic relations, there is no *a priori* difficulty in accepting the belief that their powers of song may have been developed by mutual selection, provided no adverse argument can be shown against the probability of such selection ever proving a cause of specific variation. To this last question, the question so ably raised by Mr. Wallace, I shall return on a later page.

Passing on to sight, we have first to observe the effects of mere light or brilliancy upon birds, apart from special effects of color or form. Now, birds certainly share with insects and many other creatures the common fascination for bright lights. "Owls and night-jars have been known to flutter against the window of a lighted room in the small hours." * In the tropics, where windows are more constantly left open, birds frequently fly into houses, attracted by a lamp or candle. The reflected light of a mirror is employed to draw down larks. Magpies delight in secreting diamonds, gold, silver, and other shiny objects. The bower-birds use shells, polished pebbles, and like brilliant odds and ends in the construction of their bowers. So, too, metallic iridescence occurs frequently in the feathers of beautiful species, notably in the humming-birds, sun-birds, peacocks, and other flower-feeding or fruit-eating classes. But even the far less brilliant crows, gulls, ducks, and doves show exquisitely burnished gloss or luster on their coats, often specialized upon particular portions of the plumage, and apparently betraying the action of sexual selection.

Of the love for color shown by birds, I have already treated so fully elsewhere, that it will suffice here briefly to recapitulate the main facts. The universality of bright hues in the fruits which depend upon birds for the dispersion of their seeds clearly shows that fruit-eating species are attracted by red, blue, purple, and yellow ; just as the analogous case of insect-fertilized flowers shows the preference of bees and butterflies for similar tints. Mr. Darwin has collected several instances of interest displayed by birds in colored objects, and of the attractiveness which color evidently possesses in their eyes. Of these, the most remarkable cases are those of the bower-birds' and the humming-birds' nests. And the constant occurrence of very brilliant hues among flower-feeding species, such as humming-birds, sun-birds, lories, and barbets, or among fruit-eaters, such as toucans, fruit-pigeons, birds-

* This, with several other instances, I take from an interesting article on "The Senses of the Lower Animals," in the "Quarterly Journal of Science" for July, 1878.

of-paradise, and parrots, induces the belief that in these classes the exercise of the structures upon the search for food has led to the formation of a very strong taste for color, ultimately resulting in sexual modifications.

As for the harmony of color usually observable in birds, it must be remembered that our feeling of harmony probably depends upon the due intermission and alternation of sense-stimulants, and therefore ought naturally to be shared by us more or less definitely with all other animals having a like constitution of the eye. Now, the mammalian and avian eye being derived from a common ancestor, who already possessed a highly developed power of vision, we might reasonably expect that our feelings of harmony would be essentially identical ; and this expectation is fully borne out both by the coloration of fruits and of birds themselves, which seldom or never present what we should regard as discordant coloring. Furthermore, as the most beautiful classes of birds are those which live perpetually among tropical flowers and fruits, in the most beautiful forests or meadows, surrounded by exquisite insects and reptiles, and for ever exercising their vision upon the most diversely colored environment in the whole world, it would seem far from impossible that their chromatic sensibility is even more highly developed than that of average humanity, and therefore that harmony or discord of colour would bear a relatively greater importance in their eyes than in those of any human being except the most artistically endowed. This conclusion will doubtless sound strange and even grotesque to those who are always accustomed to postulate for man a kind of absolute supremacy in the scheme of Nature ; but it appears to me almost as obvious and as simply accounted for as the superiority of scent in the dog and the deer, or of distant vision in the eagle and the vulture. Lastly, it may be noted that much of the beauty of birds, as of insects, fruits, and flowers, is due to the delicate gradation of tints which they display. But in all natural products such gradation is an almost necessary result of the mode by which they have been evolved. It is only in human manufactures, where pigment is laid on with a brush or stamp, that colors can be placed in crude juxtaposition to one another, giving rise to the worst form of chromatic discord. Doubtless our native feeling of dislike to such discords, based upon their immediately fatiguing effect upon the nerves employed, has been heightened intellectually by the knowledge that they differ so widely from the dainty gradations to be found in the handiwork of Nature. Besides being sensuously recognized as discordant, they are intellectually recognized as inartistic. Thus a large part of our art-progress has consisted in an advance from the harsh and monotonous fields of primary red and blue, divided by very hard and definite lines, which we find in Egyptian painting, to the faithful representation of graduated tints and shades which appears upon a modern canvas. But in the petal of a rose, the ray of a daisy, the wing of a butterfly, the tail-covert of a peacock, such gradual merging of tint in tint could hardly fail to occur spontaneously, as a product of evolution; while the comparatively definite marking off of special spots or lines, as in some orchids and other flowers, could only present itself as a result of very intense competition between species, carried on under highly complex conditions. The views set forth by Mr. Bates upon the progressive modification of patches or regions in a butterfly's wing, and by Mr. Darwin and Mr. Wallace on the feathers of the peacock and the Argus-pheasant, though widely differing as to the particular mode of their evolution, yet alike convince us that the inevitable result must be just such a graceful running together of contiguous colors as we actually find to obtain in every case.

Lastly, we arrive at the sensibility to form, symmetry, arrangement of patterns, and the like higher sensuous æsthetic feelings, which remains in the eyes of many the chief stumbling-block in the way of accepting the theory of sexual selection. The pleasure derived from sweet tastes and fragrant perfumes is so purely sensuous that nobody doubts its universal existence among all the higher animals. The pleasure derived from musical sounds and bright colors, though more intimately bound up in the human consciousness with intellectual and higher emotional elements, yet contains so large a factor of mere sensuous stimulation that we can easily conceive of it as appealing to the ears and eyes of insects and vertebrates. But the still higher pleasure derived from graceful curves, symmetrical ornamentation, and elaborate tracery is so largely made up of intellectual feelings, and so largely supplemented in our own case by associations of costliness, human handicraft, or imitative skill, that we find it hard at first sight to believe in the existence of similar feelings among pheasants of the Indian jungle, antelopes of the African plains, or monkeys of the Brazilian forest. Even here, however, a little consideration may convince us that the æsthetic appreciation of form and its connected varieties is not necessarily above the narrow intellectual faculties of the higher vertebrates and articulates at least.

In the first place, if we look at the human race itself we shall find that a comparatively high susceptibility to form occurs even among very low races. Indeed, most exquisite patterns are produced by savages whose taste in color is apparently far less developed than that of parrots, humming-birds, and fruit-pigeons. The tattooed tracery of the Polynesians and many other savage tribes presents beautiful designs of which even a European decorative artist need not be ashamed. The New Zealand canoes, the paddles and clubs of the Admiralty-Islanders, the shields of the Zooloos, are all most graceful in their shapes and most daintily wrought with interlacing patterns in carved work. Calabashes, cocoanuts, ostrich-eggs, and other early vessels are always cut in sections which exactly coincide with the demands of the most developed taste. The huts of savages are generally square, circular, or oval in shape, neatly wattled at symmetrical distances. The earliest architecture consists of regular stone rings, avenues, tumuli, and other definitely shaped monuments. Dr. Schweinfurth's "Heart of Africa" contains pictures of pottery as beautiful as anything ever produced in Greece or Etruria, stools, chairs, and other furniture as gracefully shaped as anything ever wrought by a Renaissance carver, and villages as prettily arranged after their simple fashion as the architects of the Parthenon or Cologne could have arranged them. If we look back in time, we find the stone hatchets and arrow-heads, not only of the neolithic but even of the palæolithic age, carefully symmetrical in shape, and that at a time when the extra labor of chipping the flints into comeliness must have entailed a considerable waste of human or half-human energy. At the same early date we find fossil shells, symmetrical bones, teeth, and other like objects, already drilled to serve as necklaces or other ornaments, which analogy with the similar ornaments now in use would lead us to believe were symmetrically strung together into definite patterns. Indeed, the more we look at the products of the very lowest savages and the very earliest men, the more shall we be convinced that they possessed in the germ all those æsthetic feelings which have finally developed our existing architecture and other decorative or semi-decorative arts.

Again, we can not fail to be struck by the fact that man has always employed for ornamental purposes exactly those very appendages of animals which, if the theory of sexual selection be correct, have been produced by the animals themselves as ornamental adjuncts. The feathers of peacocks, the plumes of the ostrich and the bird-of-paradise, the antlers of deers, the horns of antelopes, the tusks of elephants, mammoths, and musk-deer, the striped, spotted, or dappled skins of mammals, all these have been used from the earliest periods as materials for decoration by mankind. Exactly the same curls, twists, and patterns which seem to please the eyes of animals are known to please the eyes of man, even in his lowest developments. If these ornaments were not produced because the creatures themselves found them beautiful, at least they are the same as those which would have been produced had the taste of such creatures coincided in the main with that which runs throughout the whole of humanity, from the most degraded savage to the highest artist.

Moreover, part at least of the pleasure of form probably has a purely sensuous origin. The superiority of curved lines to straight, of the waving or sinuous contour to the angular, is apparently connected with the muscular process in the act of vision. Hence there is no reason why it might not be felt by intelligent animals, just as we know that it is felt, and acutely felt, by hardly more intelligent men.

Similar conclusions are forced upon us if we look at the nature of the supposed ornaments themselves. They are almost always, like the horns of several ruminants, the tail-coverts of the peacock, and the lappets or crests of many birds, apparently devoid of any functional use whatsoever, unless that use be the attraction of the opposite sex. They are also marked by the extreme definiteness of their shape, color, or sculpture—a definiteness which never occurs in similar structures among the lower animals. For though some echinodermata, as for example the sea-urchins, are very beautifully and regularly marked, yet their markings are purely dependent upon the structural arrangements of the animal, and can not generally be detected till after death. So, too, the shells of many mollusca, such as scalaria and the murices, are very beautifully sculptured; but this sculpture is structurally necessary for the animal, and apparently depends entirely upon the shape and markings of the mantle. Among birds, however, as among the ruminants, all the structures ascribed by Mr. Darwin to sexual selection are marked by a kind of definiteness, quite unconnected with ordinary functions, which it is difficult to describe in words, but which can immediately be *felt* if we compare the coloration of a peacock with that of a sea-anemone or a medusa. The former is perfectly definite without being obviously connected with structure; the latter is very indefinite, and yet bears a clear relation to the general shape of the animal. This combination of great specific distinctness with little apparent functional value appears to me the genuine hall-mark of organs due to sexual selection.

There is even some little external evidence in favor of a love for symmetry among birds. The nests of weaver-birds and many other species, as well as the bowers of the bower-birds, display a considerable taste for orderly arrangement. For one must remember that the building of such nests, though doubtless instinctive and inherited, is not a mere organic process, like the secretion of a molluscan shell; it is as much an art as the building of a honeycomb or of a savage hut. The flight of birds in play, the antics of many humming-birds, the strange eddyings and aërial evolutions of several other species, all approach very nearly to our own idea of dancing. I am almost afraid to hazard the observation, yet on the other hand I can not avoid risking it, that the attitudes taken up by the turkey-buzzards or Johncrows of the West Indies upon the tops of houses frequently seemed to me intentionally symmetrical. I have observed them sitting in every variety of position—one at each end of a long roof; one at each of the two points half-way between ends and middle; three arranged in either of these forms, with one in the middle; five arranged in the order C, B, A, B, C, etc. If any other observer can supplement this experience, which I record with great diffidence, I shall be very glad.

Taking for granted, then, this appreciation of form and symmetry, we shall find that it has produced many notable effects in the world of birds. To it, apparently, we owe the crests of cockatoos, pigeons, herons, and a hundred other species; the wattles, combs, hackles, and lappets of the gallinaceous birds; the beaks of toucans, hornbills, and cassowaries; the wonderful marking of the peacock and the Argus-pheasant. Any one who wishes really to understand the immense variety of ornamentation which has thus resulted should pay a visit to the ornithological rooms in the British Museum, and observe the innumerable devices for attracting attention which exist in almost every order of birds. Perhaps the familiar lyre-bird offers the very finest example of all, so far as beauty of form and symmetry of arrangement are concerned. It is specially noticeable, however, that in almost every case the decorations are lavished on the very same parts on which they would have been bestowed by human taste.

If, then, we put together all the scattered indications thus afforded us, if we consider the taste for sweet food and delicate perfumes, the song of the nightingale and the graceful movements of the swan, the metallic colors of the flower-feeders, the exquisite hues of the fruit-eaters, the varied plumage of the birds-of-paradise, the beautiful nests and bowers, the habit of abstracting brilliant objects, the universal loveliness of shape or tint throughout the whole class—we can hardly doubt that birds, as a whole, possess æsthetic endowments of a very high order. Let us proceed to consider the general bearings of these views upon the question of sexual selection.

Mr. Herbert Spencer, in a very remarkable essay upon personal beauty, has shown that in the human race we regard as beautiful, on the whole, just those personal peculiarities which are, roughly speaking, the external marks of fitness for the conditions of human life. More especially do we admire those points which bespeak a *physique* adapted for the duties of paternity and maternity. We dislike excessive leanness or excessive fat; a sallow or a bloated complexion; deformity or extreme departure from the normal type. On the other hand, we like in man robust and muscular limbs, an erect carriage, an open chest, a virile development of beard and whiskers, with all the other outward signs of health and strength. We like in woman a womanly and tender face, a fine and well-developed figure, and all the other outward signs of health, and more especially of healthy maternal capacities. We like in both sexes an abundant crop of hair, clear and bright eyes, white and well-set teeth, red lips, and cheeks which show a good and sound circulation; we like an expression which betokens good humor, moral qualities, and refinement; lastly, we like a face which indicates intellectual power and ability to succeed in the highly complex struggle for life in the midst of which our lot is cast. One or other of these points we may occasionally waive in consideration of other special claims; but if anybody asks in the abstract whether we prefer a stunted *physique* to well-grown limbs and muscles; a flat-chested woman to one with a finely-proportioned bust—unhealthy and sallow skin to a clear complexion; a sour-looking, mean, or brutal face to a bright, joyous, open, and honest countenance; silly or idiotic features to an expression full of liveliness and intelligence—there can be but one answer possible. Leaving out of consideration for the present all other elements of the involved and complex problem, we may conclude that beauty, from one point of view at least, consists for each species in the outward signs of specific adaptation to specific necessities.

On the other hand, beauty also consists from a different point of view of stimulation by a certain relatively fixed number of external stimulants—musical sound, brilliant light, analytic colors, curved shapes, symmetrical arrangements of form, etc.—which appear to act directly upon the nervous system. This is clearly the view which Mr. Darwin implicitly accepts, especially with regard to tone and color. The facts at which we have briefly glanced above respecting the æsthetic feelings in birds, and the beauty of the birds themselves, take for granted some such theory of the æsthetic faculty. How are we to find a reconciliation between this view and that of Mr. Herbert Spencer?

I believe the true clew has been given us by Mr. A. R. Wallace, in the able essays on "Color in Plants and Animals" which originally appeared in "Macmillan's Magazine," and were afterward reprinted in his work on "Tropical Nature." It is true that Mr. Wallace utterly rejects sexual selection as a *vera causa*, and substitutes for it several separate minor modifications of natural selection; yet it seems to me that a compromise between his view and the two other views of Mr. Darwin and Mr. Herbert Spencer would more really represent the actual state of the case in nature. Or, to put it more correctly, the three ideas are not in reality contradictory or even opposite, but are rather different and complementary aspects of one and the same fundamental truth.

Beauty in the abstract and for all species, as it seems to me, consists of pleasurable stimulation of the higher sense-organs. Such pleasurable stimulation must, on the average of cases, be given rather by brilliancy than by dullness; rather by analytic colors than by confused hues; rather by curved or flowing forms than by angularity; rather by musical sounds than by mere noises. But beauty relatively to the particular species, and especially as regards the sexual relation, must be largely due to special inherited tastes, doubtless ingrained and physically registered in the nervous system, leading the animal to derive pleasure from the typically healthy and normal form of the opposite sex. For, if any individual possesses divergent tastes, they must either be for relatively unhealthy and typically defective forms, in which case they will tend to be promptly suppressed by natural selection; or for neutral or improved forms, in which case they will help to give rise to new varieties, ultimately culminating in separate species. Such divergent tastes seem to be shown in all large dominant families, such as the humming-birds, where specific variation and ornamentation have been carried out to a very great extent. But all such divergent fancies must themselves tend to become distinctly fixed for purposes of specific identification ; and we find as a matter of fact that each species does readily recognize its mates, even when the differences between closely allied species are only very slight.

Now, this special hereditary liking for a particular form and type will not interfere with the general love for color, brilliancy, sweet tones, and perfumes. Accordingly, wherever the circumstances which give rise to a taste for these sense-stimulants exist, it would naturally follow that the taste would help to determine the choice of mates. But, again, as Mr. Wallace has fully shown, the most vigorous individuals would usually possess the most highly developed ornaments, the brightest colors, the largest scent-glands, and the loudest or most musical voices. Hence the very animals most likely to be sexually selected are also, on the average, those most likely to be naturally selected. Yet sexual selection really differs from natural selection, in that it gives a special direction to the ornamentation. For example, one can hardly believe that mere masculine vigor will account for the gorgeous and positively inconvenient plumage of the bird-of-paradise, nor for the exquisite coloring of the peacock, nor for the extremely ungainly air-bladders of many insects. It is quite easy to conceive that the general vigor implied by the possession of these extended ornamental adjuncts may have helped their possessors in the general struggle for life ; but it is hardly possible to believe that they could have reached their present definite development without the aid of sexual selection. In short, where an ornament, or what seemed to any particular individual an ornament, proved hurtful to the race, it would be eliminated by natural selection ; but where it proved neutral it would be spared, and if it coincided with advantageous qualities it would be further developed. Yet, even if only neutral, sexual selection alone would give it an extra chance, and, as it would doubtless be correlated on the one hand with certain special tastes and habits, and on the other hand with certain slight modifications of structure, it would doubtless succeed on an average of cases in producing a new species.

The familiar facts of human beauty will probably serve to make this reconciliation of the conflicting views a little clearer. Man of course admires in the abstract bright colors, brilliancy, musical notes, graceful curves, and symmetrical form. But, as applied to the human face and figure, he admires these in certain special and typical arrangements. Thus, while our general love for color leads us to prize golden hair, we do not like a sallow complexion ; while it leads us to see beauty in rosy cheeks and red lips, which are signs of a healthy circulation, we do not admire the same redness in the nose, where it is usually a result of dyspepsia or dissipated habits, either of which is bad for the race at large. Again, though we admire pearly teeth, clear eyes, and a white skin, all of which are obviously the external marks of useful properties, we do not admire white cheeks, which are the external mark of weakness or anæmia. Similarly, our idea of beauty demands that the figure should neither be too fat nor too thin, but should possess that graceful development of all the muscles which is the outward symbol of ability to move and act with ease and effect. If any large number of persons were ever actuated by opposite tastes, if they preferred pale cheeks and lips to rosy ones, thin and haggard faces to full and rounded ones, weak and angular limbs to strong and graceful ones, a flat and undeveloped chest to a fine and healthy bust, then they and their taste must rapidly die out through the inferior *physique* they would hand on to their descendants. And as every individual is himself the product of countless thousands of prior individuals, all of whom have been in the main successful in the struggle for life and the search for mates, it must follow that he will have inherited from them, on the average, a healthy taste for that particular arrangement of limbs and features which best suits the essential conditions of the species. Not, of course, that he will consciously recognize this fact in most cases ; but the mere presentation of such a typical combination will instinctively rouse in him, through the organized correlation of nervous centers, the hereditary feeling of beauty. Hence this feeling will probably be most strongly aroused in each species by the sight of the sex which in that species has undergone the greatest differentiation through sexual selection : just as we know that the feeling is most strongly aroused in mankind by the beauty of woman. On the other hand, we are still able to perceive, when we look at a peacock or a humming-bird, that, thought his specific hereditary feeling is absent, yet the strength of the purely abstract elements—color, brilliancy, symmetry, form, and minute workmanship—is so unusually great that we have no hesitation in pronouncing them also beautiful after their kind.

If, then, we admit the reality and potency of sexual selection, in however modified a form, it must follow that birds, being on the whole the most ornamental of all classes in the animal world, are also the most æsthetic, with the exception of man. It might, at first sight, seem that consistency would demand the sacrifice even of this exception ; but a moment's reflection will disclose an important difference between the two cases. Man possesses the active power of direct artistic creation ; the birds only possess the passive power of selection from among the forms produced for them by Nature. The ordinary workman who selects his wife partly or wholly on the ground of beauty, thereby does something toward perpetuating and improving the beauty of the race ; he stamps the impress of his taste upon future generations ; but such mere passive choice differs widely from the ability to depict or create on canvas such a beautiful woman. In this way, the actual loveliness of birds may lead us somewhat to over-estimate their æsthetic sensibility ; for, though within their own species they may be capable of distinguishing between comparatively minute shades and degrees of beauty, just as we can distinguish between such minute points in human faces as would doubtless absolutely escape the notice of any other animal, it is yet improbable that they would be equally discriminative outside the limits of their own species. Again the principle of "gradation of characters" necessitates certain artistic effects in their plumage which they themselves may be only half able to admire. So, too, the necessarily symmetrical arrangement of the two sides of the body and the mode of growth of feathers may often have helped, unintentionally, as it were, in producing the total effect. In other words, it may well be that the birds, while selecting their partners on the ground of bright color, exceptionally long plumes, and other ornamental characters which they *could* understand and admire, may have succeeded in producing harmonies of tone, delicate gradations of tint, and other similar effects which they could *not* understand or admire, or at least could only admire very partially.

Yet, after making all allowances for possible reading in of human feelings, it may probably be asserted with safety that the actual appearance of birds entitles them to rank, on the whole, higher in the æsthetic scale than any other animals except man. Whether we look at their graceful shapes, in the swan and the heron ; their beautiful plumes, in the ostrich and the bird-of-paradise ; their exquisite color, in the sunbird and the lory ; their ornamental crests and lappets, in the humming-birds, the pigeons, and the parrots ; or their song in the linnet, the mocking-bird, and the nightingale—we must confess that they give extraordinary evidence of a taste for all that man considers lovely or artistic. And this is just what we might expect from their free mode of life, their rapid motion, their highly developed senses, their comparative freedom from enemies, their long and almost uninterrupted rivalry between themselves for the possession of their mates. Especially should we expect this splendid outburst of æsthetic sensibility exactly where we find it in its greatest glory, among the flower-haunting and fruit-eating species of the Brazilian forests, the Indian jungles, and the Malay Archipelago. Surrounded for generations and generations by gorgeous orchids and trumpet-creepers, from which they sucked the stored-up nectar, by gleaming purple or golden fruits, by burnished beetles, metallic butterflies, bronze-scaled lizards, and coral snakes, their prey or their enemies, exercising their eyes perpetually in the search for food among the exquisite objects of their environment, and safe from almost all foes except those of their own class, tropical birds have naturally developed the most gorgeous and the most perfect forms and colors in the whole animal creation. And, above all, they have stamped the mark of their peculiarly high æsthetic feelings upon their own shapes by the wonderful definiteness of their patterns and their ornamental adjuncts, nowhere equaled, save in the most perfect decorative handicraft of man himself.

ELECTRICITY AND AGRICULTURE.

By Dr. PAGET HIGGS.

M. L. GRANDEAU, Professor in the School of Forestry, of France, was the first to point out definitely the influence of atmospheric electricity on the nutrition of vegetation.

His labors are described in the "Annales de Chimie et de Physique," for February, 1879, and he there gives the results of experiments carried out in 1876–'78.

These experiments are little known, but are of the highest importance to agriculture. As they bear upon similar experiments undertaken by the writer, a *résumé* is merited. M. Grandeau was led, from the common observation that the underwood in a dense forest disappears, to consider the influence of trees on the vegetation beneath them. Studying the causes generally assigned in explanation of this natural phenomenon, such as diminution of light, and the influence of the green light reflected by the trees, these appeared to him insufficient, and he concluded that the loss of electricity, due to the trees acting as an electrical screen, was the cause of the retarded growth—a theory that his experiments, as well as those of M. Mascart, ultimately confirmed.

The experiments consisted in placing plants under similar conditions of soil, light, and water, but covering one plant with a cage of iron-wire netting of very large mesh, the netting acting as a faradic cage, or somewhat as a lightning-conductor; the wires of the netting were one fiftieth of an inch in diameter, and the mesh six inches by four. Illustrative of the effect of this arrangement, the case may be cited of two tobacco-plants, otherwise under similar conditions:

	Without Cage.	Under Cage
Total height	1·05 metre	0·69 metre
Number of leaves	14	10
Weight of fresh leaves	107 grammes	70 grammes

Chemical analysis showed defective nutrition in the plant placed under the cage, and withdrawn from electric influence. These experiments were greatly extended, and trials were made as to the relation of electrical effect and nitrification of the soil, and the assimilation of the ammonia of the atmosphere by plants. The results are summed up by M. Grandeau as follows:

"That trees withdraw, for their own profit, electricity from the atmosphere, and insulate, as completely as a metallic cage, the plants they cover. Insulation produced by a high tree can extend to the extreme limits of its foliage. A plant withdrawn from the influence of atmospheric electricity is subject to marked retardation in its development, so that the quantity of living substance in insulated vegetation is from thirty to fifty per cent. less than the production in free air.

"The transformation of chlorophyllic protoplasm into glucose, etc., appears particularly influenced by atmospheric electricity.

"Flowering and fruit-bearing are subject equally to modification. Electricity does not appear to favor the direct combination of the nitrogen of the air with oxygen, nor with the hydrocarbons of the soil; but it exercises a remarkable influence on the nitrification of the nitrogenized matters of the soil by the intervention of the plant as an electrical conductor. Atmospheric electricity is, therefore, a preponderating factor in vegetable production."

These considerations induced the writer to carry out a series of experiments to ascertain the effect on vegetable development of a surcharge of electricity.

It would appear, from the primary consideration of intensified electrical conditions existing in tropical climates, that the more rapid growth of tropical vegetation might be due to higher electrical force. To the resident in tropical climes such a proposition would be beyond the limits of theory, because of the constant observation of the great development in vegetation during and immediately after a thunderstorm.

The experiments undertaken by the writer gave results that leave no doubt that the growth of vegetation may be enhanced twenty-five to fifty per cent. by the judicious application of electricity.

These experiments consisted in placing upon two marble slabs, one of which was carefully insulated, ten plants of the kind under trial. On the insulated slab was raised an iron structure with depending points, arranged to discharge into the atmosphere surrounding the plants the electricity produced by an induction-machine at an estimated potential of about four thousand to five thousand volts. This arrangement and difference of electrical condition, other conditions being the same, were maintained day and night for eight months, resulting in unmistakable increase in the development of the surcharged plants. The practical application of electricity to the hastening of the development of vegetation is easy. Above the plants or among them may be placed a number of metallic points on a framework insulated from the earth. Wires carried by small balloons—India-rubber or collodion bladders filled with gas—to a considerable elevation would collect sufficient of the electricity of the atmosphere, which would be imparted to the points, and these would discharge slowly to the earth, saturating the atmosphere in the neighborhood of the plants. The cost of such an arrangement would be small, and that great advantages are to be obtained from it is undoubted.

ZOÖLOGICAL EDUCATION.*

By Professor W. S. BARNARD.

IT is the office of education to direct the mental growth of the individual; and this should be by a developing and not by a cramming process. In our present system there is too much burdening of the verbal memory, and too little of what may be called the objective memory, resulting from the exercise of the mind upon actual objects. What we want is more observation, more inductive reasoning, judgment, understanding—in short, intelligent thinking; but how little do we find of this in the prevalent method of education in institutions of all grades!

Ordinary courses of study do not include subjects upon which these various mental activities can be sufficiently employed. They consist too much in learning rules pertaining to language and mathematics and their deductive applications, and too little in the objective investigation of things, the making of generalizations and the investigation of laws. School facts and deductive sciences are means instrumental to business success; but they are not in themselves sufficient to carry on the work of mental development. But, even where natural science is taught in public schools, it is generally for a short time, late in the course, and by the old method of memorizing or parroting from books instead of making it a constant study of concrete objects, to which some time should be devoted on two or more days of each week throughout the student's whole career. This learning of nature from books alone is an impossibility, a deception, and a fraud, like the teacher's "can't for want of time and specimens," when the crops are suffering from insects which swarm everywhere, and the chief amusements of the boys are to go hunting and fishing.

Teachers should utilize what they can obtain by the help of students. This is dangerous for the unfitted instructor, because he will be constantly approached with new specimens and with questions he can not answer. Yet it is better to have books of reference at hand and look things up, or have the student do it, than to be robbed of the benefit. I knew a Western teacher who formed a class of students every year in some study of which he knew little or nothing, in order that he himself might be profited by learning with them. Those who teach other things well may venture to strike out boldly and improve themselves in some part of natural history of which they were ignorant at the outset; because it is better to swim than sink, though of course a good preparation is preferable.

No field is better calculated to improve the inductive functions

* Read at the University Convocation, Albany, New York, July 13, 1880.

than that of zoölogy—the highest department of biology—while some of its divisions are to be highly recommended on account of their great economic importance. The agriculturist has to deal directly and practically with only the two highest branches of the animal kingdom, with the jointed animals known as vertebrates and arthropods. To the first of these man himself belongs, and it is now admitted that the best and most practical way to acquire a knowledge of human physiology, anatomy, and development, is by studying the comparative physiology, anatomy, and embryology of vertebrates. Also, because our domestic animals belong to this group, with many of our friends among the birds, snakes, lizards, salamanders, toads, and fishes, it deserves special study. To the second branch belong the crab-like animals, the myriad-legged forms, those which are spider-like, and true insects, which are the highest of their branch. These we meet everywhere, at every step. They are the most abundant of all organisms, their number of species exceeding that of all other animals, with all the species of plants taken together. Every terrestrial plant and animal has its insect-pests, and these in turn have insectean destroyers, which are indirectly friends to the animal or plant. With the cultivation of extensive areas, the destruction of beneficial insects, of birds and reptiles, and their forest-homes, with the introduction of new food-plants, and adaptive changes in the food-habits of insects, we favor the multiplication of our native pests, while to these we have added through commerce all the foreign marauders which can be brought with imported produce, and without the enemies which retard their increase in their own countries. At least thirty species of our most objectionable insects are derived from the Old World, among which are the dreaded currant-worm, the cabbage-worm, the cabbage-fly, the Hessian fly, the wheat-midge, the bee-moth, the apple-worm, the cabbage-lice, grain-weevils, the house-fly, the European cockroach, carpet and clothes moths and bugs, the asparagus-beetle, and the clover-beetle. This group is commanding more and more attention by the great increase of its depredations from year to year.

For all these reasons, insects appear in near and important relations to man. On these accounts, but also because of the endless variety of wonderful and interesting habits and instincts among them, is their study especially recommended. Not only is the natural history of such creatures of practical value, but there is a peculiar fascination in its study that is highly beneficial in its influence, aside from the pleasure it affords. This is expressed by J. B. Hartwell as follows: "My soul is vexed, from day to day, because the writers of unrighteous fiction are so popular, while the devotees . . . of science and the promulgators of God's truths are to such a degree neglected, their writings unsought, unread. Yet not wholly so. I rejoice to believe that the number of students in the school of Nature is rapidly increasing. And I devoutly pray and hope that the beauties and attractions of nature may be so unfolded and presented that the youth of America may be turned from the unprofitable, innutritious, and demoralizing food of fiction to the bread and water of a true life."

The facts, details, and technicalities of this science are too immensely numerous to be taught with any great degree of thoroughness, except to such as make a life-specialty of the study. Yet a knowledge of its most interesting and important facts, principles, and methods, unencumbered with a strict scientific nomenclature, can be so quickly imparted as to bring it within temporal possibilities.

All educational institutions, and public schools especially, should be *required* to teach vertebrate and entomological zoölogy in a thorough manner, while the general characteristics of the other branches and a few of their more common and curious representatives should be briefly studied in addition.

The only way to bring practical entomology to agricultural minds generally, to the class with whom it is of greatest importance, is to *require* that it be taught in all public schools. It is a kind of knowledge which the young country student grasps easily and successfully when deprived of its unessential technicalities. Of such practical consequence is it, that it had better be taught at the expense of almost any other study of the usual courses, and some attention to it would be a great relief from unnecessary problems in abstractions which are often inflicted to a useless extent in early training.

It is a sad result of the failure to teach natural science in the public schools that our cultivators do not recognize their own interest and duty with reference to insects, and need to be forced by law to a sense of its importance, even when they appear as a great scourge and leave famine in their trail. Entomological legislation with respect to the locust plague in the West, like the German insect-laws ("Abraupgesetzen"), has been to a considerable extent beneficial, though it is often difficult to force the execution of such laws. There are strong reasons why we should have a set of insect-laws for all the States. They would be as useful and as easily enforced as the "game-laws," and those prohibiting the harboring of certain noxious plants, or of nuisances against which boards of health are organized. Only by some such arrangement can farmers be compelled to coöperate for their own interests and successfully combat the thieves which are robbing them of their produce, for there are plenty whose sense of obligation can only be aroused through government influence, and who will not educate themselves in this subject unless forced to it. Laws, even if not executed successfully, instruct the people as to their duties. We need legislation to enforce—1. The teaching of entomology and vertebrate zoölogy. 2. Coöperation in destroying insect-pests. 3. The protection of beneficial insects. 4. The protection of useful birds and their eggs, whether game-birds or not, throughout the entire year.

Where can the schools and teachers get the incentives and helps they need to prosecute the work proposed for them? They can obtain these through the influences of legislation, of educational boards, and of our higher institutions of learning. Members of educational boards especially should see that this new work be introduced and continually performed.

Here will naturally arise the question, What is being done in this line at Cornell University? Besides the general course in zoölogy, there are special courses pertaining to vertebrates and insects. In the anatomical department, the special anatomy of the domestic cat is worked up as a standard of comparison, and is followed by the anatomy of examples of the leading groups and of the domestic animals, while in the entomological department special attention is devoted to those insects which are most injurious or beneficial, or otherwise, of unusual interest. Our very complete collections illustrating these insects and their habits in all their stages of transformation exhibit almost everything pertaining to the subject, and are in glass cases where they can be studied at all times. Instruction is also given in the use of antidotes and other devices for opposing objectionable kinds. At the same time students may elect in any term special and advanced courses in—1. Economic entomology. 2. Systematic work on the classification of some group. 3. Comparative anatomy and histology of insects; or, 4. Comparative embryology and metamorphoses of insects or insect-biologies. These zoölogical studies are conducted with reference to their practical relations to the cultivation of crops, to the breeding and medical treatment of domestic animals, to human physiology and hygiene, and to the doctrines of evolution.

THE ENGLISH PRECURSORS OF NEWTON.

THE seventeenth century must be regarded as the most memorable in the history of science; our own age has been remarkable for the skillful application of scientific analysis, but it has not produced a Bacon and a Galileo, a Harvey and a Newton. Between 1600 and 1700 theoretical knowledge received an increase far outweighing in importance the sum total of what has been achieved between 1700 and the present time. The definitive acceptance of the true theory of the world, and its triumphant establishment on a basis of universal and harmonious law; the constitution of physiology as a science by the great discovery of the circulation of the blood; the vast stride made in mechanics by the clear recognition of the laws of motion; the knowledge of the fundamental truths relating to light and color; the foundation of the sciences of magnetism, electricity, and chemistry—are all due to that period. The nineteenth century is not more pre-eminent for the invention of mechanical agencies by which the external conditions of human life have been revolutionized than the seventeenth for the production of those momentous "aids to sense" *—the telescope, microscope, barometer, and thermometer—by which an indefinite series of new worlds have been annexed to the domain of human intelligence. In the abstract region of mathematics, the performances of the epoch under consideration are equally remarkable. By the invention of logarithms, calculation was hardly less expedited than communication has been in our time by the discovery of the electric telegraph; while the differential and integral calculus, through the enormous increase of power conferred by it, might not inappropriately be termed the steam-engine of the intellect. Yet, notwithstanding the utilitarian character of the prevalent philosophy, inventions of practical utility remained comparatively rare; and no advance, corresponding in any degree with that accomplished in science, was made in the comforts and conveniences of every-day life. Thus, by a singular irony, a generation which sought in its experiments "fruit," found "light"; while our own age, which, with the dying Goethe, demands "more light," has received, instead, "fruit" not always sweet to the taste.

To Englishmen the seventeenth century is rendered of peculiar interest by the circumstance that, during its course, the center of scientific progress was shifted, through the overwhelming force of genius, from the Continent to this island. When it opened, our countrymen were in the position of disciples; when it closed, they were recognized as the teachers of Europe. The advance made in the interval was enormous. In 1600 Tycho Brahe was still inculcating at Prague the geocentric theory of the universe; Galileo was expounding the "sphere" on Ptolemaic principles; Harvey was listening at Padua—the "*Quartier Latin* of Venice," as M. Renan has called it—to the cloudy conjectures of Fabricius as to the purpose served by the valves in the veins. In 1700 the "Principia" had been for thirteen years the common property of mankind; Newton was acknowledged as the arbiter of science by the greater part of the civilized world; the principles of mechanics were settled on the same footing on which they stand to-day; and the last cavil against the innovation of the Folkestone physician had long ago been forgotten. We propose, in the following pages, to sketch in its broader outlines the movement of thought which led to such great results, and to devote some brief attention to a man whose career was the most conspicuous failure of the century, and who, aspiring to play the part of the Octavius, was condemned to that of the Antony of science.

Dr. Robert Hooke not only was unable to "command success," but we doubt whether he could have conscientiously asserted that he deserved it. He was original, diligent, and ingenious; but he wanted

* "Novum Organum," lib. ii., Aph. xxxix.

the concentration, disinterestedness, and, above all, the indefeasible patience, which mark the highest order of minds. Among the contemporaries of Newton, he approached most nearly to and contrasted most strongly with that great man, whose shining qualities and achievements have been set off by the convenient foil of his rival's defects of temper and fortune. It may perhaps be possible to derive a larger lesson from the consideration of his life's work than the trite moral conveyed by his exhibition in the character of the captive in the car of triumphant genius. In Newton the epoch was idealized ; in Hooke it was simply reflected. We can study more conveniently the varying impulses and undefined aspirations of a period of transition and progress in the versatility which obeyed than in the steady purpose which transformed and dominated them. The greatest men are of all time ; the lesser are an epitome of their age. They pass with it ; but they teach in passing.

Hooke believed himself to be the disciple of Bacon ; but his real instructors were men of a widely different and far less pretentious stamp. Experimental science does not date, even in England, from the "Chancellor of England and of Nature." *Roma ante Romulum fuit.* The Egremont Castle of traditional knowledge shook, it is true, to its foundations at the formidable blast of this new Sir Eustace, and the Peripatetic usurper heard in it his knell. But the fortress was already dismantled ; a numerous and unrelenting foe had silently taken possession of its outworks and bastions, and, stone by stone, was busy turning the materials of the ancient stronghold to account in the construction of habitations of more modern aspect and accommodation.

Among the multifarious forms of activity stirred into life by the ferment of the Italian Renaissance, perhaps the least questionable in its results was that leading to the love and study of nature. Two men of singular genius, Leon Battista Alberti and Leonardo da Vinci, led the way ; and their example was followed by the astronomers, anatomists, physicians, and botanists, with whom, in the following century, Italy abounded. Mathematics were at the same time cultivated with signal success ; and the learned enthusiasm which, a hundred years earlier, had hailed the unearthing of a long-forgotten codex by Poggio or Filelfo, now greeted the solution of a problem by Cardano, or the discovery of a formula by Ferri or Tartaglia. Nor did these abstract inquiries remain long unfruitful. The questions which had busied the brain of Archimedes at the siege of Syracuse began to emerge from the neglect of wellnigh eighteen centuries, and the "mechanical powers" of lever, pulley, screw, and inclined plane were once more, as our neighbors say, the order of the day. The movement was now no longer limited to the sub-Alpine peninsula. Simon Stevin, of far-away Bruges, and Michael Varro, of Geneva, deserve to be named, with Benedetti, of Venice, and Del Monte, of Pesaro, as the precursors of Galileo, whose strongest title to fame is that he first brought natural investigations under the rigid but salutary yoke of the sciences of number and of space.

In England the same impulse made itself felt, although, amid the religious troubles of the time, its effects were at first obscure and intermittent. It is, however, much to the credit of our national sagacity and boldness that, within a few years of the publication of Copernicus's great work, three Englishmen were found to advocate doctrines so novel, so startling, and so repugnant to ordinary experience as those contained in it. The introduction into England of the new views in astronomy was, in all probability, due to the notorious Dr. John Dee, the favored soothsayer of Elizabeth and Leicester, whose reputation as a mathematician has been eclipsed by his fame as a magician. His career aptly illustrates an old proverb, exhibiting the evil effects on later life of a bad name gratuitously bestowed in youth. The suspicions roused by his ingenious contrivance of an automaton-scarabæus, which, during a performance of the "Pax" of Aristophanes, visibly mounted upward carrying a man and a basket on its back, seem to have tickled his inordinate vanity, and, more than thirty years later, he hired a certain Edward Kelly to instruct him in occult arts at a salary of fifty pounds a year. Himself a dupe, he was the fitter to dupe others; and succeeded for a time in imposing his pretensions on several of the greatest personages in Europe. At length he and his spiritualistic pedagogue were compelled to retire to the castle of Trebonia, in Bohemia, where Kelly's supposed mastery of the great alchemistic secret procured them such affluence that, according to the popular belief, Dee's young son was accustomed to play at quoits with gold produced by means of the "philosophical powder of projection." Finally, the confederates quarreled; Dee was recalled to England by Elizabeth, and receiving, after the manner of that princess, more promises than pay, died in poverty in the fifth year of her successor. He left, for the benefit of posterity, a detailed record of his supernatural communications; and the magic crystal which he professed to have received from the hand of an angel may still be seen, together with Robert Burns's punch-bowl, and a casket carved out of Shakespeare's walnut-tree, among the curiosities preserved in the British Museum.

It is, however, as an astronomer, not as a spiritualist, that we have to do with him. In 1547, four years after the promulgation of the Copernican theory, he visited the Low Countries for scientific purposes, and subsequently lectured and studied at the Universities of Paris and Louvain. We may safely conclude that he there acquired the convictions which led him to instigate, and patronize with a preface, the publication of John Field's "Ephemeris" for 1557, *juxta Copernici et Reinholdi canones.* This performance has earned for Field the title of the "Proto-Copernican of England," justly due, no doubt, to the first English astronomer who adopted, *ex professo*, the heliocentric theory of the solar system. But, in a book which appeared probably a few months earlier, the same views were upheld as unhesitatingly, if not so systematically. Its author was more ingenious than fortunate. What is most certainly known of his life is its unhappy end. Robert Recorde was an eminent physician as well as an able mathematician. In his medical capacity he is believed to have been attached to the households of Edward VI. and Mary, and he undoubtedly died in a debtor's prison, the year of Elizabeth's accession. He has the merit of having introduced algebra—or, as he termed it, "Cossike Practice"—into England in a book named "The Whetstone of Witte," represented by Scott as constituting the sole literary possession of old Trapbois the miser, and as inspiring, by its very title, the young Lord of Glenvarloch with such a lively aversion that not even the desolation of a night in Alsatia could induce him to seek solace in its pages. The same writer's "Castle of Knowledge" might have proved a more efficacious remedy for *ennui.* It is an astronomical dialogue, the progress of which is enlivened by some touches of quaint satire. We take from it the following extract, noteworthy as (so far as we know) the first printed reference in the English language to the memorable innovation of the Canon of Frauenburg :

Master. Copernicus, a man of great learning, of much experience, and of wonderful diligence in observation, hath renewed the opinion of Aristarchus Samius, and affirmeth that the earth not only moveth circularly about his own centre, but also may be, yea and is, continually out of the precise centre thirty-eight hundreth thousand miles; but because the understanding of that controversy dependeth on profounder knowledge than there in this introduction may be uttered conveniently, I will let it pass till some other time.

Scholar. Nay, sir, in good faith, I desire not to hear such vain phantasies, so far against common reason, and repugnant to the consent of all the learned multitude of writers, and therefore let it pass for ever, and a day longer.

Master. You are too young to be a good judge in so great a matter: it passeth far your learning, and their's also that are much better learned than you, to improve (disprove) his supposition by good argument, and therefore you were best to condemn nothing that you do not well understand; but another time, as I said, I will so declare his supposition, that you shall not only wonder to hear it, but also peradventure be as earnest then to credit it, as you are now to condemn it.*

The objurgations of Giordano Bruno, on the occasion of his visit to Oxford in 1583, made, we can infer, but little impression on the hard-headed English Peripatetics of the time, and the Copernican system seems to have receded rather than advanced in credit during the last twenty years of the century. "How prove you," asks Blundevile in his "Exercises" (published in 1594), "that there is but one world?" "By the authority," he unhesitatingly replies, "of Aristotle!" and the inertia of his ignorance is noways shaken by his own admission that

* "The Castle of Knowledge," p. 165. London, 1556. Quoted also by Professor De Morgan, "Companion to the British Almanac for 1837," p. 36.

Copernicus, "by help of his false supposition, hath made truer demonstrations of the motions and revolutions of the celestial sphere than ever were made before." *

Already, however, the Aristotelian dictatorship was being undermined, where it could not be overthrown. William Gilbert of Colchester, physician to Queen Elizabeth (whom he only survived a few months), deserves to be called the founder of experimental science in England. In his treatise "De Magnete," published in 1600, he brought together a copious store of facts, the result of his own patient investigations, and connected them by a consistent theory, thus starting the science of electricity on a career still full of promise for the future. He was not only a Copernican, but anticipated Galileo in an important correction of the Copernican theory, pointing out the fallacy by which a so-called "third movement" was considered necessary to account for the parallelism of the earth's axis of rotation.† In his youth he had studied on the Continent, and his works were there in great repute, while his own countrymen probably shared the half-contemptuous estimate of Bacon, who placed him but a degree higher than Paracelsus and the alchemists in the school of "fantastic philosophy."

With the opening of the new century, progress became more rapid. Harriot, the friend of Raleigh, made notable advances in algebra, and was among the earliest of telescopic observers; Napier published in 1614 his "Marvellous Canon of Logarithms"; and Harvey, whose theory of investigation was as sound as his practice was successful, began his immortal lectures "On the Motion of the Heart and Blood" in 1619. In the same year was born, at Toxteth, near Liverpool, a man whose name would assuredly have been as illustrious as it is now obscure, if a premature death had not cut short his labors before they had well begun.‡ Jeremiah Horrocks belonged to a Lancashire family of little pretension and less means. His puritanism was signified by his entrance at Emmanuel College, Cambridge, and his poverty by his admission as a sizar, May 18, 1632. A passion for astronomy early seized upon him, but his tastes met with neither encouragement nor cultivation at Cambridge, which at that time afforded no form of scientific training. Books were his sole instructors, and his slender resources the limit of his choice. Indeed, his short life was one continued struggle against the tyranny of material difficulties. After a residence of three years, he left the university, summoned home probably by domestic exigencies, and spent his remaining years in the daily treadmill of tuition, or some equally harassing occupation. He

* "Companion to the British Almanac for 1837," p. 43.

† "De Mundo nostro sublunari," lib. i., cap. xi., p. 165, published (posthumously) in 1651.

‡ There is no positive evidence in support of the tradition that Horrocks was born in 1619. The fact that he was in orders and held a curacy in 1639 throws a doubt upon his age, as men are not ordained at twenty.

found time, however, for astronomical observations, and in 1636 his zeal for his favorite pursuit was still further quickened by meeting with a congenial spirit in William Crabtree, a clothier of Broughton, near Manchester, one of a remarkable group of north-country mathematicians, to whom Fate was as unkind in the untimeliness of their deaths as in the obscurity of their lives. Encouraged by his new friend, Horrocks quickly exchanged the guidance of Lansberg for that of Kepler, henceforward the object of his enthusiastic but by no means undiscriminating devotion. Even in the Rudolphine Tables he discovered inaccuracies, trifling, it is true, in comparison with the boastful blundering of the reactionary Belgian astronomer, but requiring, nevertheless, careful correction; and in the accomplishment of this task he convinced himself that a transit of Venus, which Kepler had failed to predict, would actually occur on November 24 (O. S.), 1639. He had by this time taken orders in the Church of England, and been appointed to the curacy of Hoole, then a desolate hamlet situated on a strip of land half reclaimed from the overflow of the Ribble, about five miles south of Preston. It was here that, first among astronomers of all ages, he observed the passage of Venus across the sun.

The 24th of November fell on a Sunday, and, as the critical moment approached, the eager star-gazer was summoned from his telescope to his pulpit, returning, however, just in time to witness, as the clouds parted at a quarter-past three, the punctual verification of his forecast in the projection of the dark body of the planet on the solar disk. An interval of half an hour before sunset gave him time to make a series of observations surprisingly accurate considering the primitive character of the apparatus available for their execution. A telescope bought for half a crown, and a circle of six inches in diameter, traced with a pair of compasses on a sheet of paper, stood to the young curate of Hoole in the stead of all the complicated and exquisitely delicate instruments which form the intermediaries between the senses of a modern astronomer and the phenomena he observes. Horrocks did not long survive this solitary triumph of his life. After many postponements, he at length saw a prospect of one day's extrication from his conflicting employments, and fixed January 4, 1641, for a visit of science and sympathy to his friend Crabtree. On the morning of the 3d, however, he suddenly expired, thus exchanging, in a moment, his promised post among the radiant ranks of those who constitute the pride of humanity for a place in the pathetic company of "the inheritors of unfulfilled renown."

The career of Horrocks affords, throughout its course, a singular example of precocity. He matriculated at thirteen, was ordained at twenty, and died before he had completed his twenty-second year. On him, if on any man, might safely be passed the usually somewhat problematical eulogium, "He had done great things had he lived." His mind was as quick to catch the differences of things like as it was capacious to gather the similarities of things unlike. To the imaginative fervor of Kepler he joined the technical skill of Tycho, and something of the experimental sagacity of Galileo. Short as was his life, and scanty his opportunities, he still left the imprint of his genius on astronomical theory. The movements of the moon had not yet been brought within the dominion of Kepler's Laws. Horrocks first pointed out that the apparent irregularities of our satellite could be harmonized into an orderly scheme, by supposing her to revolve in an ellipse of which the earth occupied one focus—the eccentricity of such ellipse being variable, and its major axis directly rotatory. Both these conditions Newton, in his investigation of the problem of three bodies, demonstrated to follow necessarily from the law of gravitation, thereby lending overwhelming corroboration to the views of his youthful predecessor. It has been unwisely said that Newton was indebted to Horrocks for the rudiments of his great generalization. No statement could be more misleading. The passage in his writings principally relied on for its support is indeed remarkable, as containing a description of an ingenious experiment, illustrative of the compound nature of the planetary movements, used afterward by Hooke, with a fuller understanding of the conditions of the problem; and some scattered indications may be found that the analogy between terrestrial gravity and the power exerted in the celestial mechanism was evident to him, as it had been to Gilbert, Bacon, and Galileo; but we are unable to discover that his idea of central forces was notably in advance of the crude notions current among his contemporaries.

Little as we know of Horrocks, we might easily have known nothing. His legacy to posterity barely escaped total annihilation. Some of his papers were destroyed in the civil war; some perished in the great fire of London; some were carried to Ireland, and there lost. A remnant only was preserved by the care of William Crabtree, and after his death (which followed quickly upon that of his friend) passed into the hands of Dr. Worthington, of Cambridge. Hevelius, the celebrated astronomer of Dantzic, eventually obtained possession of his "Venus in Sole visa," and published it in 1662, as an appendix to his own observations on the transit of Mercury. Whereupon the Royal Society, awakening to the merits of their countrymen, commissioned one of their most distinguished members to edit what could still be recovered of his writings, and even voted, we are told, five pounds toward the expense of printing. Dr. Wallis accomplished his task satisfactorily. The *disjecta membra* of the Horroxian manuscripts, organized into a tolerably consistent form under the title "Astronomia Kepleriana Defensa et Promota," were given to the public in 1672, together with those fragments of his correspondence with Crabtree which, disguised in the uncouth Latin of the Savilian professor, constitute all our knowledge of the life of Jeremiah Horrocks.

We have already seen that his scientific enthusiasm was not an isolated impulse. On all sides men were rising up eager to devote their best energies to physical inquiries; and society, whether fanatic or frivolous, animated them by its curiosity and rewarded them with its applause. The Long Parliament appointed, July 20, 1653, a committee "for the advancement of learning." Evelyn drew up, in 1659, an elaborate scheme for the foundation of a "philosophic-mathematic college." Cowley dismounted for a moment from his "Pindaric Pegasus" to make a "proposition for the advancement of experimental philosophy," whereby "the lost inventions, and, as it were, drowned lands of the ancients, should be recovered; all things of nature, delivered to us by former ages, weighed, examined, and proved; all arts which we now have improved, and others which we yet have not, discovered." * Samuel Pepys was scarcely less interested in astronomy than in the playhouse, and gossiped with as much zest about the experiments at Gresham College as about the pageants of Whitehall. Charles I. thought of founding a scientific repository at Vauxhall; the Earl of Worcester actually bought tenements there for the purpose; Sir William Petty recommended a comprehensive plan for the "interpretation of nature whereof there is so little, and that so bad, extant in the world." This design, "breathed after" (as Evelyn says) by so many, was, at least in part, realized by the foundation of the Royal Society.

This celebrated institution had its origin in the meetings of the "Invisible College," of which Robert Boyle, John Wallis, and Dr. Wilkins—afterward Bishop of Chester and author of a novel project for traveling to the moon—were members. It was in 1645 that these, with several other no less eminent men, began to seek in the so-called "new philosophy" a refuge from the turmoil of civil war, their scientific *symposia* being sheltered either in Gresham College or the less dignified retreat of the "Bull's Head" tavern, in Cheapside. Their fortunes were destined to expand. Fifteen years later they constituted themselves a society for the promotion of experimental science, and were incorporated by royal charter, July 15, 1662.

Thus the "Solomon's House" of the "New Atlantis" received a "local habitation" in Bishopsgate Street, and Bacon's splendid fable was brought to the test of actual, if only partial, embodiment in a living institution. Nothing can be more evident than the enormous influence exercised by the "incomparable Verulam" over the founders of the Royal Society. Not only were his praises celebrated among them, but his precepts were, as far as possible, obeyed by them. Their foreign correspondents acted the part of the "merchants of light" appointed to enrich the Island of Bensalem with the knowledge of other lands. The "mystery-men," "dowry-men," "pioneers," and "compilers" of Solomon's House had all their representatives among the "learned knot," who designed

* Weld, "History of the Royal Society," vol. i., p. 51.

"To make themselves a corporation,
And know all things by demonstration." *

Their offices, it is true, were not so sharply defined, nor the division of labor so strictly enforced, as in the ideal "College of the Six Days' Works"; but the actual never fails to blur the dividing lines of the imaginary. What it is important to observe is that Bacon's "prophetic scheme" did in truth kindle the fancy of the generation which succeeded him, and that his maxims swayed their purposes. What it is equally important to observe is that, in so far as they followed his method in its larger bearings, they were on the track of discovery, and already began to pick up stragglers from the great army of discoverable truths; but the moment they descended to particulars, and took him, as it were, at his word, they found themselves in a *cul-de-sac*. It was as if an astronomer, not content with imparting a means of taking the longitude, should attempt to prescribe rules for managing the ship, and the sailors, finding that flapping sails and fouled rigging invariably followed upon a literal compliance, should finally come to the conclusion to steer their course on scientific principles, but handle the ropes as nautical experience might suggest.

What, then, is the truth as regards the vexed question of Bacon's influence on the progress of science? We take it to be this: His capacious imagination enabled him to grasp, and his vast powers enabled him to guide, a movement which he had not originated. He caught up the floating ideas of his time, spread them abroad by his eloquence, sank them deep by his enthusiasm, gave them universality and consistence by his sagacity, and thus not unworthily earned the title of the "Father of the Inductive Philosophy." It must be confessed, indeed, that the great "Secretary of Nature" was entirely deficient in what we may call official training. His lucid thoughts and splendid diction were not coupled with exact knowledge or scientific experience. He was innocent of mathematics. He was grossly ignorant of astronomy. He knew nothing of Kepler. He despised Galileo. He passed over in silence the most fruitful discovery in physiological, and the most striking invention in numerical, science that had been made since the world began, although both were made in his own time. He ranked among the "idols" besetting the human mind that orderly instinct which recommends, *prima facie*, the harmonious simplicity of the Copernican hypothesis in preference to the outrageous complexity of the Ptolemaic system. He cumbered his phraseology and confused his argument by the adoption into physical reasoning of the metaphysical abstractions of the schools, and weakened his philosophy by the rejection of their deepest wisdom.

Bacon was in truth the English representative of that abortive but

* MS. verses signed "W. G.," quoted by Weld, "History of the Royal Society," vol. i., p. 79.

brilliant school of thought to which belonged Ramus, Patricius, and Bruno. His relations were far closer with the Cosentine than with the Lyncean Academy. As far as he was the disciple of any man, he was the disciple of Telesius, its founder. Although his name was commonly associated with that of the Tuscan astronomer as inventor of the philosophy of nature, he was in reality the English Campanella rather than the English Galileo. He was Campanella with a sounder understanding, a deeper insight, and a larger humanity. To Campanella's prophetic zeal he united incomparable practical sagacity. He not only preached a millennium of universal knowledge, but endeavored to guide men's halting footsteps toward the goal, and to bridge the gulf between the future toward which he pointed and the present to which he belonged. Hence his profound and persistent design was to establish a method, not to found a school. The message that he had it in him to deliver related to men's works, not to their thoughts. His speculative teaching not only was subordinate to his physical precepts, but was suggested by them, and displays the characteristic defects due to such an origin.

Thus his intellectual progeny divided itself into two classes—those who developed the philosophical principles implied rather than professed in his writings, and those who adopted, or endeavored to adopt, the scientific method of which the "Novum Organum" exhibits the majestic *torso*. Among the first we reckon Hobbes, Locke, and Hume in this country, and abroad, Bayle, Condillac, and the Encyclopedists—all of whom, while setting themselves problems which Bacon had ignored, and solving them, for the most part, after a fashion which Bacon would have repudiated, carried out, nevertheless, to their extreme conclusions doctrines in some degree countenenced by his great name. To the second class belonged Boyle, Hooke, Wren, and the other early members of the Royal Society. These men inherited the labors and the spirit of those who had worked while Bacon taught—of Harriot, Gilbert, Napier, and Harvey; but they were born while the air still vibrated to the mighty words of Verulam. They then enrolled themselves under the banner which he had unfurled, and silently followed the examples which he had condemned. They identified him with a system which he had disowned, and with acclamation proclaimed him leader of a movement which he had emphatically declared to be unfruitful. While professing to follow where he led, they in truth carried his authority captive with them along the paths they themselves chose. This, indeed, was the result, not of insubordination, but of necessity. They were compelled to seek a *modus vivendi* between the conflicting claims of Nature and her interpreter, and they found the conciliation that they sought not very far from the modest courses of their predecessors.

It is not too much to say that what was distinctive in Bacon's system was impracticable, and that what was practicable was already common property. The essential novelty on which he relied for the infallibility of his mode of interrogating Nature was his method of exclusions. But this ingenious invention implied an impossible preliminary, and rested on a monstrous assumption. The preliminary to its successful operation was the compilation of what he called a "Natural History"; that is, an exhaustive catalogue of all natural phenomena, constituting a vast repository of materials for induction. Until this should be accomplished, he laid down dogmatically that no progress worthy the human race was possible,* and declared the history without the method to be infinitely more serviceable to science than the method without the history.† The assumption was that the infinite complexity of visible and sensible objects is formed by the varying combinations of a limited number of "simple natures" (such as heat, weight, color, etc.), just as words and sentences in endless diversity are compounded out of a few elementary signs.‡ And as, by learning six-and-twenty letters, we get at the secret of written language, so we have only to construct a complete alphabet of Nature, in order to read her riddles with ease and certainty. Thus the second step in the process was nothing less than to frame a synopsis of all the modes of action in the universe.§ The peculiar efficacy of the "Exclusiva" now becomes apparent. All "natures" save one being excluded by a series of skillful experiments from causal connection with the phenomenon under investigation, the residual element is negatively, but conclusively, proved to be the "true cause" or "form" sought for.

It was from this special invention, and not from the general application of inductive rules, that Bacon's "Organ" derived its peculiar efficacy. This was the new art of discovery likened by him to a pair of compasses, armed with which the least skillful hand might be guided to define a perfect circle. This was the universal nostrum—*the elixir vitæ* of science—which had the one drawback common to all methods professing to transcend nature—that its operation was clogged with an impossible condition. It is easy enough for us, from our present point of view, to see that the method of exclusions was tainted with a logical vice. It implied a *petitio principii;* it presupposed, while promising to impart, universal knowledge. It was not so easy—it was perhaps impossible—for Bacon, for his contemporaries, and even for his immediate successors, to see this. They did not in fact perceive any impossibility in a scheme for tabulating the universe. On the contrary, they looked forward confidently to the time when it should be accomplished. The preparation of a universal history of nature

* "Works," vol. i., p. 394, Spedding's edition.

† Ibid., vol. ii., p. 16.

‡ "Novum Organum," lib. i., p. 121.

§ The sixth division of the Second Book of the "Novum Organum" was to have been entitled "De synopsi omnium naturarum in universo"; but this part of the work was never executed.

was a purpose always present to the minds of the founders of the Royal Society, and some preliminary steps toward its execution were even attempted by them. Bishop Sprat* has left on record the "queries and directions, what things are needful to be observed," composed with this view. Some of these inquiries sound, to our instructed ears, rather comical. We take the following specimens:

Whether diamonds and other precious stones grow again after three or four years, in the same places where they have been digged out?

Whether there be a fountain in Sumatra which runneth pure balsam?

Whether in the island of Sambrero there be found a vegetable with a worm for its root, diminishing more and more, according as the tree groweth in greatness?

What ground there may be for that relation concerning horns taking root and growing about Goa?

Whether there be a tree in Mexico, that yields water, wine, vinegar, oyl, milk, honey, wax, thread, and needles?

The answer to this last query, furnished to them by one of their "merchants of light," was, that "the Cokos tree yields all this and more."

The disproportionate importance attached to this species of information by the revivers of science is curiously illustrated by the fact that the funds of the Royal Society having been exhausted in printing Willughby's "History of Fishes," they were obliged to decline undertaking the publication of Newton's "Principia." Indeed, one of their most ingenious members was as fully convinced as Bacon had been, that the true highway to that knowledge which is power lay in this direction. Of this remarkable person it is now time to give some account.—*Edinburgh Review.*

[*To be continued.*]

NIGHT-SCHOOLS IN NEW YORK AND PARIS.

BY ALICE HYNEMAN RHINE.

THE system of night instruction is so widely different in Europe and America that the following statistics are given with a view to show which of the two methods, as represented by the schools of New York and Paris, has been most successful and of most practical utility to its students.

At the present time there are in the city of New York thirty-two free evening schools. *Thirty-one* of these are primaries or intermediates for *children;* the remaining one is the evening high school, which

* "The History of the Royal Society of London," 1667, p. 158.

is for adults, as a certain degree of proficiency in various studies must be attained for applicants to gain admission.

The students in these schools represent almost every branch of industry in the city. Yet at the commencement of the term of 1879 *two weeks* were devoted by teachers to an examination of the *moral fitness* of applicants for admission—more strictness, the reports tell us, being observed than formerly as to the character of admitted pupils. In consequence, as many were rejected as unqualified as were permitted to attend.

No difference is made in New York in the *system per se* which governs the day and night schools. Some slight changes, however, mark the manner in which it is worked.

The hours of attendance in the night-schools are limited to two. The opening and closing formalities, which are distinguishing features of the day-schools, are omitted. And in the evening high school, although sixteen different books are on the list of studies, choice of subjects is voluntary with pupils. Two classes are instructed each evening by each teacher—the first from seven to eight o'clock, the second from eight to nine. Students are required to be present only when their classes are in session.

With such apparent liberty in the high school in regard to time and choice of subject for study, it has surprised those having charge that the attendance during the second month of the course for 1879 diminished from fifteen to twenty per cent. Remarking upon this unprecedented falling off, the principal of the school says that "there are few of those admitted who do not begin their work zealously, and I doubt not with strong determination to continue during the whole term." But this enthusiasm soon cooled off, and after a few weeks the students who had commenced study so earnestly deserted the schools. This high percentage of absenteeism, however, was principally confined to the younger scholars, adults availing themselves to a greater degree of the educational advantages offered.

In the primary and intermediate schools the number of children who were enrolled as applicants for admission into the evening classes during the past year was 10,269. All of these were under sixteen years of age. The absenteeism among them amounted to sixty-one per cent. of all whose names were placed upon the school registry. Vigorous measures have been suggested to check what is called by the Board of Managers "this deplorable decrease in the attendance of children." Principal among these has been a proposal to enact a truant law, to be enforced during the evening hours. If such a formula were passed, it would be as unavailing as King Canute's edict to the waves. Natural law would prevent its being obeyed.

Of the children who did attend the evening schools the assistant superintendent makes the following remarks in his last report: "Hundreds of young children attend these schools after the labors of the day have ended, being required to do so either by parents or employers; and, as they enter the class-rooms fatigued by such labors, unless the teachers can attract, interest, and instruct them, they will either become drowsy or resort to mischievous acts to keep awake."

This simple record is in itself a pathetic protest against a system of children's night-schools. If mere book-learning was all that its most earnest champions advocate, it would still be purchased too dearly by forcing growing girls and boys into crowded schoolrooms at night after a day of toil in factories, workshops, or crowded bazaars.

Taking Paris as a representative of European methods, we find that no such absurdity is committed there as the establishment of night-schools for children. The name of these institutions implies their mission. They are called "*cours d'adultes*," and are intended solely for pupils over sixteen years of age.

Their method of instruction contrasts with that of New York, by being in its character not only scholastic and commercial, but artistic, and to a constantly growing extent industrial, technical schools for mechanic arts being a marked feature of night instruction.

Choice of subjects in the *cours d'adultes* is entirely optional with pupils. And, as more circumstances are likely to arise preventing night attendance than day, the night-schools of France are perfectly free to all who desire entrance—even the formality of registering names not being required from applicants seeking admission.

All tuition at night in Paris is given in the form of lectures by competent professors. These lectures, embracing all subjects of study, are made both instructive and attractive by illustrations and experiments whenever possible. It is found that students learn more from these popular lectures than during hours of wearisome study. They also make familiar the technical names of things relating to different pursuits, and thus enable the multi tude to read intelligently such books as treat in a scientific manner of the higher branches of their avocations. By making knowledge pleasurable, the schools of Paris, in marked contrast to those of New York, are crowded nightly by audiences desirous to learn.

Another special feature in night education in France, which would bear transplanting to America, is the *school library*. In 1877 there were 7,764 of these civilizers of men in France; the number has grown proportionately greater since then—five hundred new libraries having been instituted the past year of 1879. These libraries are either in the schools or school-wards, sufficiently near to be used for purposes of reference. The state has set aside a yearly sum of 120,000 francs for the purchase of books. Thus these libraries acquire a constantly increasing size and value.

Many of these free libraries, however, are not due to the state, but to the liberality of private individuals, who make strenuous efforts for their institution in localities where needed. All of these are accessible to others than pupils—in fact, to all who wish to use them, parents as well as children—and are open for reading *fourteen hours* out of every *twenty-four*.

For this system of scholastic and industrial schools, as well as the school libraries, the total expenditure of the French Government for the whole of France was about *fourteen million dollars* for the past school year. The number of students this sum paid for educating has been estimated at 4,700,000.

Educational appropriations reach a much larger sum than this in the United States, proportion of population considered. New York alone has spent for educational purposes for the past eight years from ten to eleven millions annually. In 1876 eleven and a half millions was disbursed; this was the largest sum ever paid out by the State. Since then the expenditures have somewhat decreased, the returns for the past year showing a smaller sum than any previous year since 1871. The total, however, reached considerably over ten millions. The number of pupils this sum educated (?) was 1,030,000. From these statistics it may be seen that New York pays more than three times as much per head for giving a merely scholastic and commercial education as it costs France to combine these with the artistic and industrial features, including a system of free-school libraries.

If this large outlay of money gave New York in return a more law-abiding, cultured, and self-helpful population, it would be capital well expended. That it does not do this is to be seen in the yearly increase in the appropriations for prisons, reformatories, and charitable institutions of all kinds. In fifteen years taxation has been more than doubled in the State of New York for purposes of public charity. Much of this evil may be laid to the fact that the industrial schools of the great capitals of Europe furnish New York with her best artisans. To remedy this, private enterprise and liberality have founded several industrial schools in New York. Statistics show these to have been well attended. Indeed, the applications for admission have in all cases been far in excess of the accommodations supplied. These night-schools, five in number, are mostly modeled upon the plans of the industrial schools of Paris and Berlin, and of South Kensington, London.

SKETCH OF JOSEPH LEIDY.

By EDWARD J. NOLAN.

IN 1849, Dr. Harvey, the author of the "Phycologia Britannica," describing his visit to the University of Pennsylvania, remarked, "There I met several persons, among whom was Dr. Leidy, a young man who will be famous if he lives and goes ahead according to present promises." The promises have been fulfilled. The young man of 1849 has gone ahead, and is now the most distinguished naturalist of America.

Joseph Leidy was born in Philadelphia, September 9, 1823. His father, Philip Leidy, was a native of Montgomery County, Pennsylvania, and his ancestors on both sides were Germans from the valley of the Rhine.

His taste for natural history was exhibited at a very early age, and received judicious encouragement from the master of the school where he acquired the rudiments of an English education. In his leisure moments he, like many other boys of his age, was fond of collecting colored pebbles and curiously shaped leaves long before he had ever heard the words mineralogy and botany. An itinerant lecturer, who described himself as belonging to the "Universal Lyceum," having one day been permitted to deliver a discourse to the school on minerals, his remarks being illustrated by specimens of quartz, mica, feldspar, etc., the boy's interest was so actively engaged that he procured for himself text-books of mineralogy and botany, and began the systematic study of the two branches without any further encouragement or assistance.

At the age of sixteen he left school, with the intention of becoming an artist, as his father proposed. It is evident, therefore, that the remarkable talent as a draughtsman, which has been of such service to Dr. Leidy in his scientific work, was apparent at this early age, and it is not improbable that the world in gaining a brilliant naturalist has lost a distinguished artist. In the mean time, however, much of his leisure had been passed in a wholesale drug-store near his home. His time here was so well spent that the proprietor did not hesitate, when an opportunity offered, to recommend him as competent to take temporary charge of a retail drug-store belonging to a customer. He was encouraged, by his success in filling the trust thus reposed in him, to study the properties and art of compounding drugs as a profession.

His study of nature while thus occupied had not been neglected. To botany and mineralogy he had added comparative anatomy, his first practical studies in that branch having been made on an ancient barn-door fowl and a common earthworm. So absorbed did he become in his anatomical studies, that at the suggestion of his mother, and with the consent of his father, he gave up all intention of becoming either artist or apothecary, and resolved to devote himself to that profession which would afford him the best opportunity of pursuing those studies from which it was now evident he could not easily withdraw himself.

In the autumn of 1840, therefore, he began the study of medicine, devoting his first year to practical anatomy. Having entered the office of Dr. Paul B. Goddard, he attended three full courses of lectures in the University of Pennsylvania, presented a thesis on "The Comparative Anatomy of the Eye of Vertebrated Animals," and graduated as Doctor of Medicine in the spring of 1844.

Immediately after receiving his degree, his first work in connection with the university was as assistant in the chemical laboratories of Drs. Hare and James B. Rogers. He began the practice of medicine in the fall of 1844, and continued it for two years, when he resolved to devote himself wholly to teaching. This course he has never had occasion to regret. His qualifications, natural and acquired, would undoubtedly have secured for him brilliant success as a practitioner, but his work as student and teacher has brought him not only satisfactory pecuniary reward, but also other things to which he attaches far more importance—peace of mind, sufficient leisure to pursue his favorite studies, and freedom from the toils and responsibilities which attend the daily life of the practicing physician.

In the winter of 1844, in addition to his work in the laboratory of Dr. Rogers, he assisted Dr. Goddard, who was then Demonstrator of Anatomy in the university. While yet a student he had attracted the attention of Dr. Horner, the Professor of Anatomy, by his success in making a beautiful preparation of the ducts of the lachrymal glands, and this interest was sufficient to secure his appointment as Prosector to the chair of Anatomy in the winter of 1845.

In the year 1846 Dr. Leidy was elected Demonstrator of Anatomy in the Franklin Medical College. He held this position, however, only during the first session, and the next spring again associated himself with Dr. Horner, and gave a private course of anatomical lectures to his students and others.

In the spring of 1848 he accompanied Dr. Horner to Europe, and enjoyed, for the first time, a long-desired opportunity of examining the museums and hospitals of England, Germany, and France.

On his return he gave a course of lectures on microscopic anatomy, and in the spring of 1849 began a course on physiology in the Medical Institute, but owing to ill health, induced by incessant labor, he was obliged to take a rest extending over several months.

In the spring of 1850 Dr. George B. Wood was transferred from the chair of Materia Medica to that of Practice of Medicine in the University of Pennsylvania. Desiring to form an illustrative collection of specimens, models, and drawings, he was accompanied to Europe by Dr. Leidy, whose services in the selection of the material required will be evident to those who visit the museum of the university.

In the winter of 1852 Dr. Horner, who had been in ill health for some time, was unable to continue his course. With the consent of the Board of Trustees, he appointed Dr. Leidy as his substitute, and so acceptable to faculty, trustees, and students were the lectures delivered in completion of the course, that, on the death of Dr. Horner, Dr. Leidy was elected Professor of Anatomy in the spring of 1853.

During the war he was surgeon to Satterlee Military Hospital. His special duty was to report on the more important *post-mortem* examinations made, and several of these reports, with beautiful illustrative drawings, are published in the "Medical and Surgical History of the War."

In 1871 he was appointed Professor of Natural History in Swarthmore College, a position which his natural aptitude for imparting scientific information makes pleasant to him.

Apart from the record of his intellectual activity there is but little more to be stated regarding Dr. Leidy, for we are of the opinion that in an article of this kind a eulogium would be out of place, although in the present instance there is every temptation to write a warm one. Since his election to his professorship in the University of Pennsylvania, Dr. Leidy's life has been the placid one of the student. At the earliest possible moment he had resolved to depend wholly on his own efforts for a livelihood. The struggle had been severe, the work incessant, and the success achieved at the early age of thirty years was due, not at all to social or family influence, but solely to personal merit. Since 1853 his published works have been his "footprints on the sands of time," and it only remains to allude briefly to the more important of these, and to his connection with an institution which in no small degree has been instrumental in enabling him to secure his present enviable position in the scientific world.

In 1844 Dr. Amos Binney, who then contemplated the publication of his superb work on the terrestrial air-breathing mollusks of the United States, was desirous of employing an anatomist who was also an artist, to dissect and draw the internal organs of the species to be described. On the recommendation of Dr. Goddard, Dr. Leidy was selected to take charge of the work. The result was the production of sixteen plates, giving the anatomy of thirty-eight species of native mollusks with a beauty of finish and accuracy of detail which have never been excelled. Dr. Leidy afterward wrote the chapter of the introduction entitled "Special Anatomy of the Terrestrial Mollusks of the United States."

Dr. Binney's intention, after the work had progressed sufficiently to demonstrate the ability of the artist to render much higher service than that of a mere draughtsman, was that Dr. Leidy should give a complete anatomical and physiological description of the terrestrial gasteropoda of the United States, including the special and general anatomy, with the embryology of the several genera. Before the special anatomy was completed, however, the death of Dr. Binney put a stop to the work. Referring to Dr. Leidy's dissections and drawings, Dr. Binney very justly remarks in his preface, "They constitute the most novel and important accession to science contained in the work, and are an honorable evidence of a skill and industry which entitle him to a high rank among philosophical zoölogists."

Dr. Leidy's studies of the terrestrial gasteropods excited the attention of the leading naturalists of Philadelphia, and quickly brought him into communication with Cassin, Morton, Phillips, Bridges, Gliddon, Gambel, Conrad, Vaux, Pickering, and other leading members of the Academy of Natural Sciences. Community of interests led to an intimate association with those gentlemen, and he was elected a member of the Academy in July, 1845.

His first published communication, entitled "Notes on White Pond, Warren County, New Jersey," was presented to the Academy in October of the same year, and so active from that time was his work in connection with the society that, at the annual election, in 1846, he was elected chairman of the Curators, a position which he has since uninterruptedly occupied. With characteristic modesty he has frequently declined the presidency of the society, and has contented himself with the quiet, unostentatious performance of the very important duties of chairman of the Curators. The respect and personal affection with which Dr. Leidy inspires every one brought into intimate communication with him, together with his practical good sense and knowledge of the needs of a large collection of objects of natural history, have enabled him to act with great efficiency in his office for the good of every department and interest of the society. He has been also a number of years chairman of the Library and Publication Committees.

Shortly after assuming his position in the university, Dr. Leidy edited an edition of Sharpey and Quain's "Anatomy," with a view to supplying the wants of his class while preparing a manual of his own. The latter was published in 1861, and for clearness and accuracy of statement and convenience of arrangement has not been equaled by any other elementary treatise on human anatomy in the English language.

Dr. Leidy's earlier scientific work was confined to no specialty. The whole field of Nature lay extended before him, and innumerable were the objects of interest which engaged his attention. Hence one is surprised to find how almost encyclopedic is Dr. Leidy's knowledge of natural history. Although he has published little or nothing upon either mineralogy or botany, his knowledge of both these sciences is rather that of one who devotes himself specially to them than that of the casual student. The pages of the "Proceedings" of the Academy for 1845 and 1846, however, indicate that his favorite field of research during that time was among the lower animal forms, and that his microscope was often brought into use. The anatomy of spectrum femoratum (Say), new species of entozoa, the mechanism which closes the wings of grasshoppers, the situation of the olfactory sense in the gasteropods, and new species of planarian worms, were among the subjects upon which communications were published in rapid succession during the first two years of his connection with the Academy.

In October, 1846, he recorded the occurrence of a species of trichina in the hog, and stated that he could perceive no distinction between it and *Trichina spiralis* which he had met with in several human subjects in the dissecting-room, since attention had been directed to it by Mr. Hilton and Professor Owen. Leuckart afterward acknowledged that he was indebted to this communication for his success in tracing the development of trichina in the hog and man.

In September, 1847, he published his first paleontological paper, entitled "On the Fossil Horse of America," in the "Proceedings" of the Academy. The existence of remains of extinct horses on the American Continent had been regarded with incredulity, in consequence of the entire disappearance of these animals in after-ages. The paper consists of descriptions and figures of specimens contained in the Museum of the Academy of Natural Sciences of Philadelphia, some of which the author regarded as belonging to the South American form, described by Owen under the name *Equus curvidens*, and others as indicating a new species, for which he proposed the name *Equus Americanus*.

His investigations on the development of cartilage-cells, the structure of the liver, of the nettling organs in hydra, the presence of the first indication of muscular fiber in the gregarines, the discovery of the eye in the perfect condition of the cirrhopoda, together with descriptions of many new forms of entozoa and entophita, miscellaneous anatomical and zoölogical notes, and a continuous series of papers entitled "Helminthological Contributions," enriched the pages of the "Proceedings" of the Academy during the next four or five years. His elaborate memoir on the "Anatomy of Corydalus Cornutus in its Three Stages of Existence," published in the "Memoirs of the American Academy of Arts and Sciences," and his beautifully illustrated monograph entitled "A Flora and Fauna within Living Animals," issued as part of the fifth volume of the Smithsonian contributions to knowledge, merit special mention.

These communications, laboriously prepared as many of them were, did not, however, indicate the full extent of Dr. Leidy's industry. Since the publication of his paper on the fossil horses of America, much of his time had been occupied in the study of the vertebrate fossils in the museum of the Academy, or which were brought to his notice from time to time by collectors. Long before the active exploration of the West had added so immensely to our knowledge of the extinct fauna of that region, he had determined the former existence, in a tropical climate on our western slope, of the lion, the tiger, the camel, the horse, the rhinoceros, and many other forms having no immediate existing representatives.

In 1853 the Smithsonian Institution published his memoir on the extinct species of American ox, and in the following year the elaborate "Ancient Fauna of Nebraska." Other paleontological papers were published in the "Transactions of the American Philosophical Society," and many new genera and species were announced in the "Proceedings" of the Academy. The extent to which Dr. Leidy was absorbed in his paleontological studies, between the years 1854 and 1872, may be judged by the fact that, out of seventy-two communications published during that period, only thirteen were on the subjects to which he had formerly devoted his attention, and these were, for the most part, brief reports of verbal communications made before the meetings of the Academy.

In 1869 his memoir entitled "The Extinct Mammalian Fauna of Dakota and Nebraska" appeared as the seventh volume of the journal of the Academy. The work, a quarto of 472 pages, illustrated by thirty lithographic plates, is the result of the gradual accumulation of material during twenty-three years. This elaborate work was followed in 1873 by one of equal importance, under the title "Contributions to the Extinct Vertebrate Fauna of the Western Territories." It forms the first volume of the superb quarto reports of the survey of the Territories, under Dr. Hayden, and consists of 354 pages and thirty-seven plates.

For many years after the publication of his paper on fossil horses, in 1847, Dr. Leidy was almost the only American author whose attention was given to the study of the extinct vertebrata. The wonderful remains brought to light by the explorations under the direction of Dr. Hayden had, however, excited the interest of others, and private expeditions, as well as the official surveys, had collected rich stores of vertebrate fossils, in some cases from the same localities whence came the material submitted to Dr. Leidy's examination. The anxiety to obtain early publication of descriptions of supposed new forms became so great that, in at least one instance, such description was telegraphed to a learned society from the field. The dispatch was published with as little delay as possible, but the paragraph contained so many errors that the experiment has not, we believe, been repeated. In the attempt to settle questions of priority, the published arguments became so bitter and the personalities indulged in so pronounced that Dr. Leidy, who had been able to refrain from taking part in the controversy, finally withdrew from the field. With characteristic amiability, he had remarked in the preface to his last-named work: "The investigations and descriptions of some fossils from the same localities have been so nearly contemporary with my own that, for want of the opportunity of comparison of specimens, we have no doubt in some cases described the same things under different names, and thus produced some confusion which can only be corrected in future." And, while others were making anxious inquiries regarding dates of issue, and personal bulletins were followed rapidly by bitter little notes of reclamation, he placidly held to the belief that the future would undoubtedly award the credit where it belonged, and withdrew to resume the studies which he had prosecuted so successfully in former years. The only paleontological communication of importance which he has since published is his "Description of Vertebrate Remains, chiefly from the Phosphate Beds of South Carolina," in the eighth volume of the journal of the Academy.

Finding that the activity and enthusiasm of the younger naturalists, who had taken up the study of the extinct fauna of the West, were quite sufficient to guarantee the prompt use of the fine collections which still continue to be received from that region, and constitutionally indisposed to take part in the battle for priority, Dr. Leidy availed himself with pleasure of the opportunity to study a group of minute organisms to which he had already given some attention. For the next four years he devoted all his spare time to collecting, studying, and delineating the fresh-water rhizopods of America, and the results of his work are embodied in the twelfth volume of the report of the United States Geological Survey of the Territories. The memoir is entitled "Fresh-water Rhizopods of North America," and is perhaps the best illustration of Dr. Leidy's qualities as a naturalist, and the most enduring monument to his industry, which has yet appeared. While preparing the work he spent the greater portion of two seasons in the West, under the auspices of the Survey, and made careful explorations of the country about Fort Bridger, the Uintah Mountains, and the Salt Lake Basin, in search of materials for the memoir.

Since the issue of this superb monograph, Dr. Leidy has been engaged in preparing a new edition of his manual of human anatomy. When this is finished, he intends collecting material for an elaborate illustrated work on parasites. He will probably publish, in the next number of the journal of the Academy, a paper on the parasites of the white ant, many curious forms of which were brought to his notice during his studies of the rhizopods.

The value of Dr. Leidy's scientific work has lately been substantially recognized by the Council of the Boston Society of Natural History, which awarded him the Walker Prize. On account of the extraordinary merit of his researches, the prize, which usually consists of the sum of $500, was on the occasion increased to $1,000.

In the performance of the great scientific work thus imperfectly recorded, Dr. Leidy has confined himself to the duty of accurately describing what he has seen. He very rarely draws inferences from his accumulated facts, and his innate truthfulness is such as to deter him from theorizing. As a lecturer he rarely indulges in figures of speech or flights of fancy. He is deliberate and lucid in his statements, some of his word-pictures being so nearly perfect as to make the fine blackboard drawings with which he often illustrates his remarks almost unnecessary. His delight at acquiring knowledge of a new fact is only equaled by his pleasure in communicating it to others.

CORRESPONDENCE.

A CORRECTION.

Messrs. Editors.

IN an article published in the July number of your magazine, I said, in speaking of the red-bellied nuthatch, "The author of 'Land and Game Birds of New England' notes that a nest was found in Roxbury in 1866."

This reference should have been to the "Birds of New England," by Samuels.

I can not comprehend how I made this error, for my notes from which I wrote referred distinctly to Samuels's work.

To-day I have learned that Mr. Samuels was wrong in stating that the nest he referred to was found in Roxbury, as it was taken in the Adirondacks by Mr. Minot, a brother of the author of "Land and Game Birds of New England."

I might add that by typographical errors the scientific names of the Loggerhead and Great Northern Shrikes were slightly changed: the former should have been *Collurio ludovicianus*, and the latter, *C. borealis*.

Respectfully yours,
HARRY MERRILL.

BANGOR, MAINE, *July* 7, 1880.

ANIMALS AND THE FACULTY OF DIRECTION.

Messrs. Editors.

I HAVE read Dr. Oswald's "Zoölogical Enigma" in the July number with great interest. One step toward determining by what means animals accomplish such feats must be to find what animals possess the power. The following, which came under my own observation, shows that it exists in the hog:

Some six years since, in one of the New England States, a pig five weeks old was carried in a close box about four miles. The route was very circuitous, with several sharp turns, and the pig was removed from the box to the sty after dark. The following day, near noon, he disappeared, and about three hours later was found at his former home. Curiosity led to the examination of the route taken by the pig, and his tracks could be followed nearly all the way. He had started on a straight line for the place from which he was brought the day before, and had followed that line. At one point an impassable fence turned him from the course, but he had moved along the fence on one side until he found an opening, and then had retraced his steps on the other back to the original line!

LA ROY F. GRIFFIN.

LAKE FOREST, ILLINOIS, *June* 25, 1880.

ABNORMAL ACTION OF OLFACTORY NERVES.

Messrs. Editors.

AN old acquaintance relates that for several months past his nerves of smell have been singularly and strangely acted upon. For instance, in early spring the air would seem loaded with the odors of fresh, ripe strawberries; at other times of peaches and other fruits—the odors were distinct and pungent, while the season and circumstances precluded the possibility of any such fruits being in the vicinity. At other times offensive odors (occasionally very offensive) would seem to indicate the immediate presence of well-known offensive substances, where it was known they were not present. Sometimes, however, odors either pleasant or unpleasant would seem to pervade the air which were unrecognized or new.

In all these cases locality was entirely disconnected with the odor; as, although the subject often changed his locality, to the extent of miles, it produced no diminution of odor. These attacks continue from hours to days.

If we assume the *undulatory theory* in the sense of smell, and that particles from all odorous substances, each through their own peculiar vibration or motion, impinge upon the nerves of the nasal cavity, and thus from the peculiarity of movement rather than of substance produce the sense of smell, may we not assume that the nerve is thrown into a peculiar *condition*, by the motion of the odorous particle, and this condition, repeated through the nerve to the brain, produces the idea of that peculiar smell? Again, may not diseased or unnatural action of itself, or through the aid of other agents, set up *conditions* usually and naturally obtained from what we term odorous substances, and thus induce false reports and ideas? Diseased action alone, or in connection with other than the natural substance, might produce the peculiar condition.

Have we not a like exhibition of perverted function in the nerves of taste under the action of disease? As also to the nerves of feeling in the sensations of heat and cold, in agues, chills, etc.? And may not this same *condition* of the optic nerves explain the various enigmas of optical illusions? Indeed, may not the nerves of each and all of our senses be subject to abnormal conditions, and thus become unreliable?

These queries, affirmatively answered, would enable us, in the mass of contradictory testimony of different individuals as to *facts*, to transfer the charge of much moral to physical obliquity.

A. L. Child.

Plattsmouth, Nebraska, *August* 5, 1880.

EDITOR'S TABLE.

THE AMERICAN SCIENTIFIC ASSOCIATION.

THE American Association for the Advancement of Science will hold its twenty-ninth annual meeting in Boston, commencing Wednesday, August 25th, and continuing perhaps a week. It is expected that this will be the largest and probably the most important scientific gathering yet held in this country; and ample arrangements have been made, by a large and efficient local committee, both for the business accommodation of the body in all its departments and for the convenience and pleasant entertainment of the members and guests who may be present.

The purpose for which this Association was established is very well known, but to strangers, who propose attending it, it may be well to say that it is devoted to original researches, which are generally of interest to those only who have paid some attention to special scientific branches. Neither the papers read nor the discussions that follow them are usually of a popular character. They are necessarily dry and unintelligible to those unfamiliar with the subjects; but, to those who have some preparation in science, even though it be of a general sort, there is much in the proceedings of this society that will be found very instructive. It is broken up into a large number of sections, each devoted to a division of science, such as astronomy, physics, chemistry, zoölogy, botany, physiology, geology, anthropology, etc., and programmes are published every morning giving lists of the papers to be read during the day in each section. Though technical, and addressed to specialists, these papers represent the advances in each branch of inquiry, and the proceedings of the successive meetings may be looked upon as comprehensive reports of the annual progress of scientific research.

Any person may become a member of the Association upon recommendation in writing by two members, and subsequent election by a majority of the session. The initiation fee is five dollars, and the subsequent annual dues three dollars; and these payments entitle each member to receive the annual volume of proceedings. New members are usually elected daily during the meeting, but many apply earlier to the permanent Secretary, Mr. F. W. Putnam, Cambridge, Massachusetts. More than two hundred members had been proposed for the Boston meeting a month before it begins.

The sessions of the Association will be held in the Massachusetts Institute of Technology. The address of the retiring President, Professor George F. Barker, of Philadelphia, will be given on the first day, and the new President-elect, Dr. Lewis H. Morgan, of Rochester, will be the presiding officer of the Boston meeting.

SEWAGE IN COLLEGE EDUCATION.

At the College of New Jersey, in Princeton, a considerable number of students were recently attacked by a malignant fever, of which several of them died. It turned out that the cause of this fatal outbreak was not the unhealthfulness of the place, but bad sewage arrangements in the college buildings, where the unfortunate students resided.

There was, of course, nothing new or unusual in such an occurrence. There have been thousands of cases like it before. Indeed, as we go back in the centuries we read of great fever-plagues carrying off millions of people, and which were caused by air-poison and water-poison engendered in the filth of human habitations, when the methods and the virtues of sewage and drainage were unknown.

And yet there was something unexpected and startling about this affair at Princeton. The sickness and death that occurred there were not from want of knowledge. The calamity was entirely preventable. It could not be charged to the mysterious providence of God, as is often so plausibly done when the causes of disease and death are not understood. It took place in a great seat of learning, where young men gather to be educated. The business of the place was to think. But if there was knowledge sufficient to prevent this disaster, and the young men were learning how to use their minds, why did the catastrophe occur? The answer is, these young men *were sacrificed to an educational theory.*

The theory to which the Princeton students were offered up is that college knowledge is not to be of the useful kind that is necessary to save life. Utilitarian knowledge—that which instructs people how to preserve life and maintain health, and deal intelligently with practical affairs—is decried in these institutions as vulgar and unfitted for educational purposes. Knowledge for its vital life-uses is flatly repudiated, and the courses of study are made up with reference to quite other objects. The study of dead languages, which, for general students, is most perfectly freed from all utilitarian taint, is the earliest, the most prolonged, and the most prized of all college studies. The whole pressure goes in this direction. Whatever else is neglected, the Greek and Latin are always insisted upon. The students are told that this will make men and scholars of them, while an acquaintance with modern knowledge, science, and the laws of their own nature is hardly to be ranked as education at all. A knowledge of sewage is not included in the Princeton ideal of scholarship, nor is it exacted by the Princeton curriculum. There was information enough to prevent the calamity that happened there, but nobody had any interest in making use of it. It was dead knowledge in the College of New Jersey. The intellectual interest fostered by the institution impels to other acquisitions. The whole battery of examinations, honors, prizes, is adapted to favor dignified, traditional, and disciplinary studies. The Princeton student is not, first of all, thoroughly instructed in regard to the laws of breathing and the circulation, nor of the brain and its conditions of action and limits of endurance, nor of the nervous system and its perils of exhaustion, nor of the stomach with its dyspeptic dangers, nor of the vital forces of the living system and the laws of their economical exercise, nor of the complex influence of environing conditions over human health, efficiency, and enjoyment. He is not taught these prime essentials of welfare as the most imperative of intellectual requirements, because they are slurred as mere "utilities"; and so he is left to die or sicken from poisonous air, or to undermine his energies and break down his health in any of the numberless ways to which carelessness, ignorance, and unregulated ambition may lead. If he does not die of collegiate sewage, he is turned adrift with his "miserable scrapings of Greek and Latin," to find out by bitter experience that it would have been better if he had devoted more of the precious time of his college years to the study of useful things.

We have spoken of the college at

Princeton because it happens to have furnished us with a text; but these strictures have a wider application, for the vice we are condemning vitiates the college system of the country. There may have been excuse for this in institutions founded long before the claims of modern knowledge had anything like their present urgency; but the later colleges exhibit the same defects. The University of Michigan, for example, is of modern origin, having been established nearly a hundred years later than the College of New Jersey, but its educational spirit is of the same kind. It was organized by State authority, and has been maintained from the beginning by public taxes. It is open to all within the State or out, and, excepting a slight initiation fee, is free to every student. One would think that the circumstances were here favorable for giving precedence to that later, higher, and more perfect knowledge which is vindicated in its beneficent uses, and is equally valuable to all classes. Yet this great institution, with its fourteen hundred students, seems just as much enslaved by vicious traditions as the older schools. Middle-age studies are still in the ascendant, as "three years in Greek required for A. B." sufficiently attests. The sciences are taught there, but the classical course is the one encouraged by the whole weight of the university influence; and, consequently, as statistics show, it is the one pursued by an excessive majority of the students. The theory of education which bore its fatal fruit at Princeton is loudly defended at Ann Arbor. A newspaper comes to us with report of the proceedings of the last commencement, held July 1st. These are grand occasions, when the colleges are sure of public attention. A vast audience gathered at this thirty-sixth annual commencement of the Michigan University, but, in place of the usual speeches by the graduating students, an elaborate address was delivered by the Right Rev. Samuel T. Harris, D. D., Bishop of Michigan. The eloquent speaker did not fail to improve the occasion in the interest of all collegiate traditions. Knowing that they are under indictment by the common sense of the age, he came to their defense with a kind of fanatical desperation. The Bishop said:

Scarcely less cruel is the introduction of a false utilitarianism into education. In education the usefulness of a study is not to be measured by its availability for the business purposes of later life. In education those things are useful, not which may be employed thereafter for business purposes, but which best develop and train the student's faculties and powers. Until education is completed, no student ought ever to be permitted to study anything simply because he proposes to make money by it. It is not the object of education to learn useful things, but to become able to learn and use them. So I say it is a cruel wrong to the student to permit either the instruments or the spirit of mere money-making to be introduced into his educational life. Permit me to say that this is a great evil of which I am now speaking. In too many cases education is dwarfed and perverted by the tendency to yield to this false utilitarianism. In too many cases allurements of worldliness and mammon are allowed to call our ingenuous youth away from the proper objects of education. In too many cases short roads and by-paths are opened up to tempt them away from the proper work of the college and the university, and so to send them prematurely to schools of professional and technical instruction. The result is, that too often we see half-educated men and unformed men sent forth to plead the cases and heal the diseases and lead the thinking of the age. Let us all protest against this evil tendency. For, unless we succeed in checking it in some way, it will lead to the impoverishment of this generation. Let our schools and our colleges and universities make men first, and then let them make lawyers and physicians and teachers. Ordinarily, so far as education is concerned—and we are confining our discussion to that now—the only path to true completed manhood is through a thorough course of educational training. Latin and Greek and the higher mathematics, rhetoric and logic and mental and moral philosophy, these are the useful studies in education. These are the studies by which such men as Newton and Bacon and Stevenson and Butler and Gladstone were made. I rejoice to believe that a steadfast adherence to this principle does characterize the counsels of this institution. I rejoice to learn that the number of students who take the full classical and philosophical course is steadily increasing. I rejoice to believe that this fell spirit of utilitarianism is not nourished in this place, and I devoutly hope that the time is speedily coming when no one but those who have taken the bachelor's degree will expect to be admitted to the professional schools of this great university. [Great applause.]

We take exception to this greatly applauded statement on several accounts. Bishop Harris recommends a course of collegiate study, and rejoices in its popularity at the Michigan University, in which not a single one of the natural sciences is included. He assumes that the scientific progress of three centuries goes for nothing in the higher education; and he admits no improvement upon the mediæval scheme of culture. The most developed form of knowledge, that which has created modern civilization, and opened up a new world of truth to the human mind, he passes by as if it had no existence. He advocates the theory of college education of which Princeton has recently illustrated the practice—the theory to which students are immolated. It is an insult to the intelligence of the age. Any college, supported by forced exactions upon the people, which omits the sciences from its curriculum, is an outrage upon the community; and, if it can not be reformed, deserves to be suppressed as a public nuisance.

Again, we object to the Bishop's disingenuous attempt to bring useful knowledge into reproach by talking of "mammon," "worldliness," and "money-making," in connection with it. It is not true that the advocates of educational reform put the educational claims of modern knowledge on mercenary grounds. Does Bishop Harris need to be reminded that there are other uses of scientific knowledge than sordid uses? Does he need to be told that it subserves the highest ends to which knowledge is applicable? Would students be chargeable with a venal purpose if they neglected their Latin and Greek, and took up the study of sewage to protect themselves from fatal college epidemics? The Bishop reprobates in his address the "false and superficial habit of object-teaching"; but if students should take up college buildings as an object-lesson, and thereby gain some knowledge that might not only be of immediate utility, but have a vital value for them through life, who but an infatuated classicist would accuse them of being animated by low and degrading motives? And supposing they should systematically extend this practice and look into the water-supply of Ann Arbor and the sewage of the town, and then examine the hygienic conditions of the public schools, and afterward proceed to the jail and the poor-house, and get up a series of object-lessons on these also, would they be liable to the imputation of being actuated by motives of mere vulgar and debasing utility? This disparaging assault upon the kinds of knowledge which lead to self-preservation, to the maintenance of health, to the promotion of personal and public welfare, and to an understanding of the laws of the human constitution, the natural laws of society, and the principles on which the surrounding world is ordered, was wholly unworthy of the orator, of the occasion, and the university that he represented.

And we can not refrain from saying that his insinuation about making education subservient to business comes with an ill grace from the Right Reverend Bishop, whose education was a direct preparation for his trade. He says, "Latin and Greek, and the higher mathematics, rhetoric and logic, and mental and moral philosophy, these are the useful studies in education." Undoubtedly! but useful to whom? They are the staple studies of the clerical profession. They are the acquisitions by which clergymen get a living. Our old colleges were all originally seminaries for training professional divines. The traditional curriculum was shaped for the uses of a vocation. Clergymen have been the heads of the colleges for centuries. Every President of the College of New Jersey, for a hundred and twenty-seven years, from Dickinson to McCosh, has been a professional divine. Greek and Latin, rhetoric and logic, and mental and moral philosophy, which Bishop Harris would palm off upon the Michigan boys as giving the only true education, have been the bread and butter of doctors of divinity ever since divinity became a regular business. Let Bishop Harris confine his pot-boiling curriculum for preachers to the technical schools of the profession, the theological seminaries. It is high time that general education were rescued from this slough of specialism and placed upon loftier grounds.

The Bishop denounces the "fell spirit of utilitarianism"; that is, the vile and pernicious impulse to usefulness. What does he think of the clerical spirit in education, as shown, say, in the history of the English universities? Under clerical domination they have notoriously been the fastnesses of bigotry, intolerance, proscription, and scandalous abuse of trust and power. Their professorships and fellowships and scholarships have been sinecures for men in "holy orders"; and the institutions have been fettered and trammeled by absurd theological tests, which public sentiment in England has been fighting for half a century, and has not even yet been able to extirpate. Those universities were ages ago the professional schools for the education of the clergy, and, under continued priestly headships, they have clung with desperation to the dominant studies of theological culture. And, as for the spirit of greed, the unscrupulous perversion of endowments and the ravenous struggle for profitable places, which have been displayed in the long hierarchical administration of those great schools, have been the disgrace of civilization. It is fit that the representative of this system should do his best to keep modern science out of the curriculum of the University of Michigan!

But it is a vain and futile work. Bishop Harris's vehement protest shows that he recognizes the strength of the new tendencies. The same newspaper that brings the report of his speech contains also the following significant paragraph: "Cornell University seems to have introduced a notable change in commencement orations and essays. Among the number chosen for public presentation this year is a paper by Mr. R. P. Green, on 'The Sewage of Ithaca as a Hydraulic Problem,' and one by Miss M. Hicks on 'Tenement-Houses, a Social Problem in Architecture.' Among the list from which these papers are chosen are several on broader subjects, as 'The Relation of Modern Science to Education,' etc." When such topics as these are earnestly taken up by students, and college studies become a fit preparation for dealing with them, society will then begin to reap the substantial benefits, which have hitherto been but scantily afforded by the higher education.

LITERARY NOTICES.

Early Man in Britain, and his Place in the Tertiary Period. By W. Boyd Dawkins, F. R. S. New York: Macmillan & Co. Pp. 537. Price, $6.50.

The subject of primitive man and his history, as obscurely traced by archæological research, has now come to be so extensive that is has become necessary to concentrate research in special directions, as the whole field is too large for any one man to cultivate. Professor Dawkins has, accordingly, taken up the question of "Early Man in Britain," and even in his elaborate volume he is unable to present the discussion in its completeness. In his work on

"Cave-hunting," published in 1874, he has cleared the way for the present inquiry into the conditions of life, the growth in culture, and the relation to history of primeval man in Britain. The present work is copiously illustrated, and its author admits that it has defects due partially to the nature of the subject, but chiefly to the swiftness with which our knowledge of early man is being enlarged by new discoveries. The author has no favorite theory to advocate, and writes with caution in reference to chronology, considering that there is little ground for placing confidence in dates. As to the antiquity of man, he thinks that we have far from settled views upon the subject. The scientific problem now is how far fossil man can be traced back into the Tertiary. There are those who hold that the early indications of the human race go back to the Miocene or Pliocene period, but Professor Dawkins finds no trustworthy indications earlier than the Pleistocene, or most recent geological period. He considers that on biological grounds it was improbable, if not impossible, that man should appear much earlier than the period marked by arrowheads, flint scrapers, etc., an opinion that he shares with some of the most competent geologists of the present time. The earliest man met with in Britain Professor Dawkins states is the hunter of the old Drift period, who had for contemporaries the grizzly bear, spotted hyena, lion, hippopotamus, rhinoceros, elephant, and most of the animals now existing. England and Ireland were then one, and were united to the continent, and possessed vastly different climatic conditions from the present. This primitive man was spread over a wide range of country, of which Britain was but a small part, and must have previously existed a considerable period of time. His successor was a man of a much higher type, who appears to have been equally widespread, and to have been possessed of much better and more varied tools and considerable artistic ability, as shown by his carvings in bone and ivory. Professor Dawkins regards him as the direct ancestor of the present Esquimau, and points out in support of his position a number of striking resemblances. The Pleistocene period closes with the diappearance of these cave-men, and neolithic civilization opens with the prehistoric farmer and herdsman. At the time of his advent, the British Islands had attained nearly their existing shape, and climatic conditions were closely allied to the present. These men were short, well built, black-haired, and of swarthy complexion. They came wandering westward from the East, with flocks and herds and some knowledge of agriculture. Before them the mild and unwarlike progenitors of the Esquimau fled, leaving but little trace behind them. The conquerors brought with them many of the arts that raise man above the brute, and overrun the greater part of Europe, and a considerable portion of Asia and Africa. They were in turn displaced by the fair-haired Celts, the van of the Aryan migration, who exterminated, moved them aside, or enslaved them. A mixture of the two races occurred over the greater part of Europe, producing the main characteristics of the peoples of modern Europe. To the neolithic period succeeded that of bronze, and this in turn gave place to that of iron, the age which includes our present civilization. With the beginning of the historic period, the work of the archæologist yields to that of the historian, and at this point Professor Dawkins takes leave of his subject.

Reports of the Peabody Museum of American Archæology and Ethnology, in Connection with Harvard University. Vol. II. 1876–'79. Cambridge: printed by order of the Board of Trustees. 1880. Pp. 775.

This goodly volume contains the tenth, eleventh, twelfth, and thirteenth annual reports, and covers the last four years of museum-work. And very able and fruitful has been this work, as directed by the zealous skill of its curator, Professor Putnam, and the craniologist, Mr. Carr, his assistant. This book constitutes a no mean monument of home work done in American archæology. Did space suffice, it would be a pleasant task to review these reports at length. Besides a good deal of matter which merely concerns the shop-work of the institution, we find twenty-two articles all devoted to American archæology and ethnology, and each one containing results of original research. Thus there are papers of first-rate significance under such names as Putnam, Carr, Abbott, Shaler, Andrews, Bandelier, Schumacher, Blake, Reynolds, and Morgan. As we retrospect American archæology, this volume assumes an interesting prominence. It is only turned a generation of years since that grand venture was made of the first volume of the Smithsonian contributions to publish Squier's and Davis's "Ancient Monuments of the Mississippi Valley." Davis's collection of antiquities, therein so well figured, was to us a sight never to be forgotten. It is about a score of years ago when we groaned in spirit with that worthy man. Misfortune had set upon him, and he must sell his treasure. Must it be said that in the whole breadth of our wealthy land neither individual nor institution could be found to give the poor man a bid? So an Englishman appears, who buys the collection, and removes it to his own country. What a change since then! Not to speak of the national treasures of the Smithsonian in this line, our country has now, through the far-sightedness of one remarkable man, its special museum of American archæology. Of the grand collection it already possesses, and the solid work it is doing, these interesting reports are in evidence.

Of course, we can not specify articles, but perhaps may say that no papers in this volume will command more attention than those of Dr. Abbott, in which he insists on his having found palæolithic implements in undisturbed glacial drift, near Trenton, New Jersey; and his claimed discovery of an interglacial (why not autochthonic?) race of men. Assuredly the Doctor shows much skill in his diagnosis, and his subject receives what the faculty might term heroic treatment. As against very high authority, he insists on a difference of action in the deposition of the gravels in his cliff, and of others in the railroad-cuts near by, albeit both are of the same geological horizon. The Doctor feels that the difference thus claimed favors his theory. Without expressing any opinion, it must be admitted that the position is argued with ability.

It is quite in keeping with the importance of the subject when Professor Putnam induced Professor Shaler to make a geological reconnaissance of the places containing the supposed palæoliths; and it should be said that the conservatism of the Professor's report shows a safe spirit, although it is, on the whole, not unfavorable to Dr. Abbott's views. We own to some surprise that this report does not so much as allude to Dr. Cook's labors. He says: "I hope hereafter to finish a detailed account of the geology of these gravel-beds." He also says: "The entire absence of organic remains in the mass proves that it was essentially a lifeless sea in which they were laid down." It may be of interest to state that, since Professor Shaler wrote his report, the New Jersey State geologist has obtained from the gravel in the railroad-cuts at Trenton a large portion of a proboscidian's tusk, which has suffered indubitable wear from water, and perhaps glacial action.

It is, we think, a fact patent to all who know what is meant by solid, patient work in the domain of science, that this new science of prehistoric archæology has drawn to itself an immense brood of callow thinkers. The merest accident of finding a few relics is supposed to constitute the text and the ability for a paper on the subject, either for some periodical or maybe some learned society. The lookout is good for American archæology in that we have so grand a school as this Peabody Müseum, and so safe a vehicle of instruction as is afforded by its annual report. The tread of Science should be stately, and her footing sure. None more than she should "prove all things, and hold fast the good." *Festine lente.* When, in these fascinating walks of grand thinkings, the imagination gets into a rush, it will be well if this institution shall provide the engineer who will whistle down the brakes.

The Taxidermist's Manual. By Captain Thomas Brown, F. L. S. New York: G. P. Putnam's Sons. 1879. Pp. 199. Price, $1.25.

This reprint, from the twenty-eighth English edition of Captain Brown's Manual, will be a very welcome book to the large and increasing class of students and amateurs interested in natural history and the preservation of natural-history specimens. The author thinks that many valuable specimens are lost because of the lack of information, among naturalists as well as amateurs, regarding the proper means of preserving them. He has, accordingly, given a clear and concise account of the art, the implements used, and the principles upon which the work should be done. The subjects considered are, the skinning, preparing, and mounting of quadrupeds, birds, reptiles, fishes, molluscous animals, etc.; the preservation of spiders, and preparation of skeletons. The choice and manner of collecting animals, recipes for various articles used in the art, and some instructions to travelers, complete the work. A half-dozen well-engraved plates exhibit the manner of mounting, and preparing the animals and tools used.

Spectres Fugitifs observés près du Limb Solaire (Fugitive Spectra observed near the Solar Limb). By M. L. Trouvelot.

The author in this pamphlet describes some remarkable phenomena which he has noticed several times in his observations of the solar spectrum. His attention was first called to them on the 30th of August, 1877, when, all at once, the spectrum was crossed, with the quickness of lightning, by extremely brilliant spectra, which succeeded each other rapidly and ran the full length of the spectrum. The phenomenon was observed on the following days to the 3d of September, the fugitive spectra varying in shape and intensity, and appearing at unequal intervals. Some moved across the solar spectrum or parallel to it, others were stationary. The fugitive spectra were next noticed at Creston, Wyoming, during the observations of the eclipse of the sun in July, 1878, and again at different intervals till the 2d of February, 1880, when the last observation described in the memoir took place. They generally came in numbers, not alone, and in spells of several days at a time, separated by intervals sometimes of months. M. Trouvelot does not derive from this any theory as to the frequency with which they may really have manifested themselves; for, though he saw them only fifteen times in thirty months, he was actually observing the sun for only one hundredth of the time during that period, and they may have been active during the other ninety-nine hundredths of the time without his noticing them. He satisfied himself by every possible experiment and form of reasoning that they were not of terrestrial but of cosmical origin. Two theories are proposed to account for them: 1. That they arise from the meteoric bodies that are supposed to be constantly falling into the sun; 2. That they come from the incandescent matter which the sun throws up in the eruptions which have been observed to take place from its surface. M. Trouvelot prefers the latter theory.

Proceedings of the Davenport Academy of Natural Sciences, Vol. ii., Part II. July, 1877, to December, 1878. Davenport, Iowa: published by J. D. Putnam, March, 1880.

Perhaps one may be pardoned for slightly altering the hackneyed citation, by asserting that "westward the star of science takes its way." In this contribution of the Davenport Academy is that of which the elder academy in the East need not be ashamed. We notice, too, this Western academy is appointing its professors after the methods of the Eastern one. In these proceedings we find original work in archæology, botany, entomology, conchology, paleontology, and embryology, and all these illustrated by plates. The most labored and lengthy article is one by J. Duncan Putnam, on the maple-bark scale-insect (*Pulvinaria innumerabilis*). This article is very exhaustive, and of great biological merit. There is a short but interesting paper by Dr. R. J. Farquharson, on the formation of ground-ice in the rapids of the Mississippi. This is a revival of the long-mooted question, How is anchor-ice made? Dr. Farquharson gives the bibliography of the subject. The Doctor's theory in a nutshell is this: that rapidly-flowing water will get so mixed that its temperature becomes uniform throughout, and when at its freezing-point an arrest of motion will favor congelation, so that there is needed "but the slack-water afforded by the eddy of a bowlder, or a pot-hole, to freeze instantly into a spongy mass." We wish this Western academy the prosperity it so well merits. For two things is this Iowa institution notable: that it is indebted for its building-site to a noble-hearted woman, Mrs. P. V. Newcomb; and its president is Mrs. Mary

L. D. Putnam, a lady to whose zeal the prosperity of the academy is largely due. We observe that a good deal of work is done in archæology, which is certainly wise, considering the richness of this Western field.

Health and Healthy Homes; A Guide to Domestic Hygiene. By George Wilson, M. A., M. D. With Notes and Additions by J. G. Richardson, M. D. Philadelphia: Presley Blakiston. 1880. Pp. 307. Price, $1.50.

This is an American reprint of the excellent work of Dr. Wilson, accompanied with a brief preface by Dr. Richardson, of Philadelphia, and such notes as the application of Dr. Wilson's statements to American sanitary condition seemed to warrant.

The book is designed to reach and interest all classes of readers, and the various subjects considered are therefore treated in a practical, untechnical manner. Dr. Wilson opens his subject by a consideration of the amount of preventable disease, which he finds to be still very great, though it has been steadily declining, and there is good reason to hope for continued improvement in this direction. Such a description of the structure of the human body and the functions of the various organs is given as will enable the reader to have a clear appreciation of the laws of health, and the causes of diseases are then explained and illustrated. Among these causes are considered heredity, personal habits, mode of living, work and worry, bad air, food and water, etc. The subject of food and diet is treated quite fully, the nutritive value of the various foods, together with a considerable amount of information of the principles of dietetics, being given. Cleanliness, bathing and clothing in relation to health, and the hygienic value of exercise and recreation, as well as the essential features of healthy houses and surroundings, are duly considered. In the closing chapter of the book the principal dangerous infectious diseases are dealt with, and their mode of dissemination, and the precautionary measures necessary indicated.

Though the work is a continuous exposition of the subject of domestic hygiene, each chapter is made complete in itself, so as to be read independently of any other. The variety and extent of the information contained in the small compass of this volume eminently fit it for household use, while the position of the author is a guarantee of the accuracy of its statements.

Water Analyses for Sanitary Purposes, with Hints for the Interpretation of the Results. By E. Frankland, Ph. D., D. C. L., F. R. S. Philadelphia: Presley Blakiston. 1880. Pp. 149. Price, $1.

This is an exposition of the most reliable means of making analyses of water by the well-known chemist, Dr. Frankland. The greater part of the book is of purely technical interest, but in the appendix Dr. Frankland has given briefly information regarding the purity and value of different kinds of water that is of concern to the general public.

He finds that the best water for dietetic purposes is that of deep springs and wells, and the worst that of shallow wells, which are usually situated near drains, cesspools, etc. Rain-water, collected at a distance from towns and upon surfaces kept clean, is next in purity to that of deep wells; that collected from roofs and stored in underground tanks is rarely good enough for dietetic purposes. Water from the surface of uncultivated land is fairly good, while that from cultivated land is not sufficiently good for domestic use, though better than shallow well-water. River-water when it is from cultivated land and is polluted by sewage and factory refuse, is always dangerous to use. Surface and river water containing more than 0·2 part of organic carbon or ·03 part of organic nitrogen in 100,000 parts, is to be avoided for domestic use when possible.

Dr. Frankland states that organic matter in solution in water is so very persistent, that sewage would not be completely oxidized and destroyed in traveling from the source to the mouth of any river in the United Kingdom. Impure water can be more or less improved by filtration through sand, spongy iron, and animal charcoal, but even this can not be relied upon to render sewage-tainted water fit for use. Boiling is probably effective in destroying the power of such water to communicate disease. Water suffers little or no deterioration in transmission even through long mains, if they be properly laid, and organic material, such as hemp, be avoided in making the joints.

Health. By W. H. Corfield, M. D., Professor of Hygiene and Public Health at University College, London. New York: D. Appleton & Co. Pp. 361. Price, $1.25.

The contents of this volume were delivered as a course of lectures at the rooms of the London Society of Arts, under the auspices of the National Health Society. It is an unpretentious but useful statement of the most important principles of personal hygiene, and the precautions necessary for the prevention of disease. Dr. Corfield's reputation as a practical student of this subject sufficiently attests the care and accuracy of his statements; and the style of the book is so plain and simple as to be easy to all readers. In speaking of the health of the individual his statement of the hereditary feature is especially clear. Half a dozen lectures are first given to preliminary physiology, and then "The Air," "Food and Drink," "Drinking-Water," "Houses," and "Communicable Diseases" are treated in the remainder of the course.

The Child's Catechism of Common Things. By John D. Champlin, Jr. New York: Henry Holt & Co. 1879. Pp. 289. Price, 60 cents.

This little book gives a large mass of information about common things, arranged in such a manner as to be interesting to and easily consulted by a child. The subjects are classified under the mineral, vegetable, and animal kingdoms, the information under each being given, as the name indicates, in the form of questions and answers. An excellent design, illustrating the inquisitive attitude of the child toward the things around him, appears on the cover.

Free Land and Free Trade: The Lessons of the English Corn-Laws applied to the United States. By Samuel S. Cox. New York: G. P. Putnam's Sons. 1880. Pp. 126. Price, $1.25.

The main purpose of this work is as an argument in favor of the principles expressed in the leading title. The author believes that "we are rapidly outgrowing the market to which our tariff walls practically limit us," and that "we must have the opportunity and privilege, the liberty, to trade," for which we must be free to buy as well as to sell. He sees, also, a great danger of a land monopoly, the first signs of which have appeared in the practices, the freight combinations, and the high rates charged for transportation by the railroads. The corn-laws of England and the land troubles of England and Ireland are discussed as affording historical illustrations of the author's views.

Sea-Air and Sea-Bathing. By John H. Packard, M. D. Philadelphia: Presley Blakiston. 1880. Pp. 121. Price, 50 cents.

This is number eleven of the monographs on hygienic subjects issued under the title of "American Health Primers." Dr. Packard has aimed to give such information concerning the subject, and such practical directions, as will be of use to those seeking recreation at the seaside. Such questions as how long to remain in the water, how to bathe, what care to take against accidents, and what to do in cases of apparent drowning, are among those considered.

Radical Mechanics of Animal Locomotion. With Remarks on the setting up of Soldiers, Horse and Foot, and on the supplying of Cavalry-Horses. By Colonel William Pratt Wainwright. New York: D. Van Nostrand. Pp. 294. Price, $1.50.

Though the heading of this work is professional, the problems it discusses are both of extreme scientific interest, and of wider application than to the training of soldiers. The writer aims to determine the fundamental mechanical principles of locomotive activity in animals of the vertebrate structure with a view to cultivating those habits of body by which movements shall become most harmonious and efficient. The point of view from which the book has been prepared is well indicated in the opening paragraph. "Many are the expedients which, in the training of soldiers, have been and still are adopted, in order to overcome that fault of body, whatever it may be, which, in ninety-nine men out of every thousand from civilized nations, tends to hinder the man from marching in a straight line, from discharging his musket without destroying his aim, from cutting perpendicularly with the edge of his saber, and which likewise hinders him from so following in his own frame the motions received from the frame of his horse that the forces enumerated by this latter shall be so absorbed into and discharged with the making of his aim, as to give no recoil from the saddle."

It is thus assumed that some fault in the play of the bony skeleton is the radical cause of the soldier's deficiencies in movement, and this fault is held to be a one-sided action, as is illustrated in right-handedness. The author takes the ground that only a man who is ambidextrous can have the perfect command and full force of the movements of his body. He holds that "the excessive use of one hand, and of the parts of the body brought into action with it, is a cause of general deformity among civilized men. This so interferes with the central-point working of the body as to greatly reduce its power of producing and sustaining action. The working of the spine is the fundamental basis of movement. Motion properly originates in the spine, is directed by the head, and is only followed up by the limbs. The snake presents the simplest type of spinal working." Colonel Wainwright makes a great deal of this last idea, showing that the locomotion of the snake, when mechanically resolved, throws light upon the work of the higher vertebrate machines. The book is curious and attractive.

The Microscope in Medicine. By Lionel S. Beale, M. B., F. R. S. Fourth edition. With more than 500 Illustrations, most of them drawn on wood by the author. Philadelphia: Presley Blakiston. 1878. Pp. 539. Price, $7.50.

We have commended the former editions of this work, which now appears much enlarged, and more deserving of the student's favor. We by no means entertain the highest opinion of Dr. Beale as a philosopher; but, as a microscopical observer, and an histological manipulator, his skill and eminence are generally conceded. This elaborate volume, on a rapidly growing branch of physiology and pathology, is entitled to a place among the standard volumes of reference in every well-supplied medical library.

The Field Engineer. By William Findlay Shunk, C. E. New York: D. Van Nostrand. 1880. Pp. 325. Price, $2.50

In this hand-book Mr. Shunk has given, in a convenient form, a clear and concise statement of the information needful for the young railroad engineer. The initial chapters give an exposition of the mathematics and methods essential as a basis for work, and following these are instructions as to the use and adjustments of instruments, with hints on field routine. A number of problems of field location occurring in the author's practice are given as covering the greater part of those likely to be met with. Very full tables, a number of which are new, are appended. The book is well printed, in clear type, and bound in leather in the ordinary form of the engineering field-book.

Hygienic and Therapeutic Relations of House-Plants. By J. M. Anders, M. D., Ph. D. Philadelphia: J. B. Lippincott & Co. 1880. Pp. 16.

In this paper Dr. Anders calls attention to the well-known property of transpiration of plants, and their value on this account as hygienic agents. He has been making some quantitative experiments, and finds that plants having soft, thin leaves, such as the geranium, exhale one and a half ounce (by weight) of watery vapor per square foot of leaf-surface in twelve day-hours during clear weather. In-door plants transpire something more than half as much in the same time as those in the open air. He is, therefore, of the opinion that growing plants are of great value in keeping the air of an apartment properly moist, and can be of considerable help in cases of consumption.

The Fabulous Gods denounced in the Bible. Translated from Selden's "Syrian Deities." By W. A. Hauser. Philadelphia: J. B. Lippincott & Co. 1880. Pp. 178. Price, $1.25.

But very little has been known by the general public of the mythology of the Jews, while that of the Greeks and Romans is part of the most familiar knowledge. Mr. Hauser thinks that, as Christianity arose among the Jews, a knowledge of the early religious ideas and habits of this people should be of interest to at least the Christian part of the modern world, and he has, therefore, made this translation from the Latin of Selden's work. This was published more than two hundred years ago, in 1617, and has been out of print nearly as long. A brief sketch of the life of John Selden is prefixed to the volume.

Practical Keramics for Students. By C. A. Janvier. New York: Henry Holt & Co. 1880. Pp. 258. Price, $2.50.

Mr. Janvier has endeavored to put in as concise and intelligible form as possible such information of the manufacture, classification, and decoration of pottery as will be of interest to the amateur. In the introductory portion he describes the materials used and their properties, supplementing this with a general description of the processes of manufacture. The various wares are fully described, and the errors of many of the names given by shopmen pointed out. The work closes with instructions and practical hints to intending decorators. A list of some of the best works on keramics and full index and glossary are appended. A handsome binding, good clear type, and heavy paper, leave nothing to be desired in the way of book-making.

We have received from Dr. Eduard Reyer, of Vienna, a pamphlet (in German) on "Tin in Burmah, Siam, and Malacca." The tin district of these countries extends from Bengal down the western coast of Farther India, and through the peninsula of Malacca to the small islands south of it. This region is believed by Dr. Reyer to be the place whence the ancients obtained their Indian tin. Considerable quantities are still produced in Malacca and the islands. The average importation of "Straits tin" into England from 1870 to 1877 was five thousand four hundred tons a year, and the importation to Dutch ports from the islands of Banca and Billitong does not fall far below the same amount. Dr. Reyer also sends us a pamphlet on "Vier Ausflüge in die Eruptivmassen bei Christiania" ("Four Excursions among the Eruptive Masses near Christiania"), in Norway; and "Granit und Schiefer von Schlackenwald" ("The Granite and Slate of Schlackenwald").

Schiller's Complete Works, in English. Edited by Charles J. Hempel, M. D. Philadelphia: J. Kohle. 1879. Pp. 1282.

This, the editor states, is the first complete edition of Schiller's works, in English, that has been offered to the American public. It contains all his poetical, critical, philosophical, and historical writings, the only things omitted being Schiller's own translations from foreign languages. The translations are for the most part by well-known literary men, and are of conceded excellence. Careful editorial supervision has been exercised by the editor, Dr. Charles J. Hempel, who also furnishes several of the translations. The work is illustrated with a large number of full-page woodcuts from the drawings of the best German artists, and is printed in clear type on toned paper. It is issued in one and two volumes, and also in parts. The bound volumes are in various styles, at corresponding prices. A sketch of Schiller's life is prefixed to the work. The edition gives an opportunity to possess the writings of one of Germany's greatest literary men, that few of his admirers will allow to pass.

Landsberg's Illustrirtes Wochenblatt (Landsberg's "Illustrated Weekly") is a new German periodical of a size corresponding with that of the other illustrated journals, having sixteen pages and a tinted cover. It bears marks of good editing and the evidence of discrimination in the selection of subjects for articles and illustrations. It is published by Silvius Landsberg, at 17 Centre Street, New York. Price, $5 a year.

"Tromsö Museums Aarshefter" is a collection of papers on scientific topics contributed to the Museum Society of Tromsö, Norway. The second part, which has been kindly sent us, contains papers on the "Coleoptera of Tromsö and the Vicinity," by J. Sparre Schneider; the "Marine Fauna of the Northern Coast of Norway," by G. O. Sars; and on "Certain Phenomena of Glacial Action along the Coast," by Karl Pettersen.

PUBLICATIONS RECEIVED.

Calendar of the University of Michigan for 1879-'80. Ann Arbor: Published by the University. Pp. 168.

Catalogue of North American Musci. Arranged by Eugene A. Rau and A. B. Hervey, A. M. Taunton, Mass 1880. Pp. 52. 50 cents.

A Classification for the Natural Sciences. By C. A. Cutter. Pp. 4.

Two Papers on Academic Degrees: 1. On the Regulation and Control of the Degree-conferring Power; and, 2. On the Origin and Significancy of Academic Degrees. By Frederick A. P. Barnard, LL. D., etc. New York. 1880. Pp. 31.

Practical Uses of the Microscope: An Address by R. H. Ward, M. D., President of the American Society of Microscopists. Indianapolis. 1880. Pp. 17.

The Three Climates of Geology. By C. B. Warring, Ph. D. Pp. 36.

Change as a Mental Restorative. By J. Mortimer Granville. London: David Bogue. 1880. Pp. 32.

Ninth Report of the State Entomologist on the Noxious and Beneficial Insects of the State of Illinois. By Cyrus Thomas, Ph. D. Springfield. 1880. Pp. 142.

Sanitary Reform in Japan; A Lecture to the Students of the University of Tokio. By J. A. Ewing, B. Sc., F. R. S. E. Yokohama. 1880. Pp. 18.

The Providence Franklin Society: An Historical Address by the President, W. O. Brown, M. D. Providence. 1880. Pp. 50.

The Influence of Language on Thought. By Professor William D. Wilson, D. D., LL. D., etc., of Cornell University. 1879. Pp. 14.

The Anthracite Coal-Fields of Pennsylvania and their Exhaustion. By Ph. Sheafer, M. E. Read at the Saratoga Meeting of the American Association for the Advancement of Science. 1879. Pp. 10.

Proceedings of the National Microscopical Congress and the American Society of Microscopists, held at Indianapolis, Ind., August 14, 1878. Indianapolis. 1880. Pp. 77.

Transactions of the Medical and Chirurgical Faculty of the State of Maryland. 82d Annual Session. Baltimore. 1880. Pp. 216.

Report made to the New Orleans Auxiliary Sanitary Association on the Construction and Management of Privies. New Orleans. 1880. Pp. 8.

Minutes of the Twenty-fourth and Twenty-fifth Annual Meetings of the State Medical Society of Kentucky. Louisville. 1880. Pp. 27.

Railway Reporter: A Monthly Journal devoted to the Interests of Railway Men. No. 53 Ninth Street, Pittsburgh, Pa. Pp. 20. Subscription price, $1.25 per year.

Advance copy of Vol. VII. of the Survey of the Fortieth Parallel. Being Memoirs of the Peabody Museum of Yale College. Vol. I., Odontornithes: A Monograph on the Extinct Toothed Birds of North America. By Othniel Charles Marsh. New Haven. 1880. 4to, pp. 201, with Thirty-four Plates and Forty Woodcuts.

The Thousand Islands of the River St. Lawrence. Edited by Franklin B. Hough. Syracuse, N. Y.: Davis, Bardeen & Co. 1880. Pp. 307. $1 25.

The Microscopists' Annual for 1879. No. 1. New York Industrial Publication Co. 1880. Pp. 48. 25 cents.

The Book of Ensilage. By John M. Briley. Billerica, Mass.: Published by the author. 1880. Pp. 202.

The Historical Poetry of the Ancient Hebrews. Translated and critically examined. By Michael Heilprin. Vol. II. New York; D. Appleton & Co. 1880. Pp. 213. $2.

A Selection of Spiritual Songs, with Music for the Sunday-School. Selected and arranged by Rev. Charles S. Robinson, D. D. New York: Scribner & Co. 1880. Pp. 192. 50 cents.

First Annual Report of the Department of Statistics and Geology of the State of Indiana. Indianapolis, Ind. 1880. Pp. 514.

An Elementary Text-book of Botany. Translated from the German of Dr. Prantl. Translation revised by S. H. Vines, M. A., F. L. S., with 275 Illustrations. Philadelphia: J. B. Lippincott & Co. 1880. Pp. 332. $2.25.

Claims of a Protestant Episcopal Bishop to Apostolical Succession and Valid Orders disproved, with various Misstatements of Catholic Faith, and Numerous Charges against the Church and Holy See corrected and refuted. By Bishop S. V. Ryan. In Two Parts. Buffalo Catholic Publication Co. 1880. Pp. 277. $1.25.

The Obelisk and Freemasonry. By John A. Weisse, M. D. New York: J. W. Bouton, 1880. Pp. 178. $2.

Naso-Pharyngeal Catarrh. By Martin T. Coomes, M. D. Louisville: Bradley & Gilbert. 1880. Pp. 165. $2.

POPULAR MISCELLANY.

American Climate and Character.—Mr. C. Edward Young, of Hartford, Connecticut, has given in "The Sanitarian" a summary of the opinions which several distinguished European hygienists have expressed respecting the influence of our climate upon the temperament and civilization of the American people. Dr. Edward Reich, in his "Studien über die Volksseele," speaks of the great difference existing between the English and Americans, although they are of the same race, and ascribes it to the contrast of the climates. The air of America, he says, "is much too dry for the Anglo-Saxon race, in point of heat too excessive; from this results the exaggerated nervous activity, the excesses of the national character, and the mad chase after the material things of the world." Dr. Max von Pettenkofer has concluded, from the investigations he has made into the comparative loss of heat experienced by a person breathing dry air and one breathing damp air, that with the dry air more heat is lost and more created, and in consequence the circulation is quicker and more intense, life is more energetic, and there is no opportunity for the excessive accumulation of fat or flesh, or for the development of a phlegmatically nervous temperament. Hence, in our dry climate is laid the foundation of the nervousness which characterizes our people. Dr. Prosper de Pietro Santa, in his "Essai de Climatologie," makes essentially the same deduction. Dr. Büchner, author of "Mind and Matter," has remarked, in a series of articles in the "Gartenlaube," that the Americans are tending toward the Indian type, and that he has observed the resemblance not only in the face and form, but also in the gestures and movements. A. Mühry, in his work on "Climatology," says that the evaporation is nearly twice as great at New York as at Whitehaven, England, hence the Americans and English live under very different conditions, and exhibit great divergences of temperament. Dr. Carl Reclam, editor of "Die Gesundheit," compares the air of America and its effects to those of heights, where the lightness and dryness favor extraordinarily the evaporation or exhalation from the body, and notices in the Americans not only the characteristic physical features induced by such an air, but also "mental peculiarities, traces of which may be seen with us (Europeans) by a careful observer during a dry northeast wind." Mr. Young gives as the result of his own observations, that "the dry air with us produces nervous, energetic, large-jointed skeletons, which have little or nothing in common with the stout, fresh, rosy, phlegmatic inhabitants of the mother-country. Not only is the physical resemblance lost in the second generation, but the mental also, and ideas especially Britannic give way to ideas peculiarly American, the product of the climate, the soil, and the habits caused by these two factors." With the English the muscular system predominates; with the Americans, the nervous. American women possess beauty of face, almost never of form; and even the beauty of face is soon worn out by the drying, irritating effects of the climate and of American life. English women have beauty of form and face, and keep both to an advanced age.

The Jablochkoff Electric Light in London.—The London Metropolitan Board of Works has recently renewed a contract for one year for lighting the Victoria Embankment and Waterloo Bridge with the Jablochkoff electric light. The Jablochkoff system has been in successful operation on the Thames Embankment since the 13th of December, 1878, when twenty lights were started between Westminster and Waterloo Bridges. Twenty lights, extending the work to Blackfriars Bridge, were added in May, 1879, and ten more were put on Waterloo Bridge in October last; ten lights have also been placed in the Victoria Railway station. All of the lights on the Embankment have been kept in operation regularly for six hours each night since they were first started—a fact that is worthy of consideration when it is borne in mind that the machinery was originally arranged for twenty lights only, with no thought that the system was to be extended, and that the changes rendered necessary by each of the two extensions have had to be made without interfering with the daily efficiency of the apparatus. The price paid by the Board of Works was, at first, 6*d.* per light per hour; it was reduced to 5*d.* in the first, and 3*d.* on the second extension, and has again been reduced on the renewal of the contract to 2½*d.* per light per hour. The Jablochkoff system of electric lighting is now in use under almost every possible condition and in every variety of establishment—in streets, on bridges, in railway-stations, theatres, circuses, engineering and industrial works, docks, basins, on board steam-vessels, in hotels, and in private residences. King Theebaw, of Burmah, has sixty lights fitted up in his palace at Mandalay; the Shah of Persia four, at Teheran; Prince Agaklam six, at Bombay; and the King of Portugal and the ex-Queen of Spain are also using them. At present, seventeen hundred and sixteen are in use in different countries, one hundred and ninety-eight being in England.

Coloring of the Waters in Seas and Lakes.—Geographers were not able to determine why the Red Sea was so named until Ehrenberg, sailing over a part of it, observed that the water of the whole Gulf of Tor was colored a blood-red. Drawing up some of the water and examining it with the microscope, he found that the color was due to a minute, thread-like, dark-red oscillatoria, or alga. The same alga was observed by Dupont twenty years afterward, giving rise to the same appearance over an extent of 256 nautical miles. A similar plant was noticed by Darwin in his voyage round the world, coloring the water near the Abrolhos Islands, off the coast of Brazil. Oersted, in 1845, noticed that the waters near Madeira had a peculiar obscurity, which was occasioned by numerous minute tufts of oscillatoria waving in the mass. These plants were found all the way to the West Indies, sometimes thick enough to give a color to the water, but never wholly wanting. In other cases the sea is colored red by animals of different kinds, by minute crustaceans or infusoriæ, or eggs. The name of Red Sea or Vermilion Sea has been given to two different phenomena in the Gulf of California, in which the water is colored two distinct shades of red by different microscopic infusoriæ. One of the coloring animals is irritating to the skin, and produces blisters and sores on the bodies of those who come in contact with it. Diatoms often give rise to similar colorings. Professor Cleve, of Upsala, mentions fifty-four species of diatoms which have been found on the surface of the Sea of Java, and speaks of others which have been observed between Europe and Greenland and in Davis Strait. Grunow gives a list of thirteen species which are found near the Nicobar Islands. Kjellmann gives especial attention to the diatomaceous flora in his treatise on the alga of the Kara Sea. The Swedish polar expedition of 1872–'73 saw on the northwestern coast of Spitzbergen an expanse of sea of considerable extent covered with masses of diatoms of a single species, forming what the English sailors call a "sawdust sea." The same has been observed in Davis Strait, in the Kara Sea, and on the northern coast of Finland, covering large spaces. Johann Steenstrup found spots in the Atlantic Ocean between Scotland and Greenland, where the water changes from ultramarine to an emerald green, so suddenly that only a line separates the two colors. The coloring seems to have some relation to temperature, the green prevailing in the warmer months, the blue in the colder, and is thought to be connected with the development of diatoms. Professor Ossian Sars, of Norway, has observed a dull grayish-green color of the sea, which he ascribes to a bathybius that he found floating on the surface of the water. Similar colorings occur in fresh water, and have received the names at times of bloody rains, bloody dews, etc. Schwammerdam, observing water thus strangely colored at Vincennes, was strongly affected by the sight, but, examining it, found that the color was given by small crustaceans. The Musten Lake in Switzerland has been colored by oscillatoria which were so thick in the water as to make it unhealthy for the fish, and to cause them to die; the fishermen are well acquainted with the phenomena, and speak—referring to the mixture of green and red—of the lake blooming. The water in one of the lakes of Denmark has been found colored a deep red by another oscillatoria. In still other cases the colors are given by the spores of an alga. The so-called "bloody rain" is colored by an alga, which, because they have not noticed it before, some believe to have come down from the clouds, while others think it was previously present but was dried up, and has only been refreshed and enlivened by the rain. It has recently been identified with the "red snow," a one-celled, spherical plant, green or red in color, which may be increased by division, and is propagated rapidly in water or melting snow. In the still waters of the coast of Denmark a red deposit appears on the decaying sea-weeds, or floats loosely on the surface, giving a raspberry-red color to the water. It is caused by bacteria, which, probably contributing to the decay of the sea-weed, are thought to have a part in the formation of the sulphuretted hydrogen gas so common in that region. Of a similar character—caused by vegetable or animal growths, often by bacteria—are the colored spots which appear on decaying food; and it can no longer be considered an occasion of marvel that a pond becomes as red as blood, or that what seem to be drops of blood may appear on the sacramental wafers. These phenomena are all assignable to natural causes which have been traced out and are clearly known.

Luminous Paint.—The invention of luminous paint is based upon the fact that certain substances after having been exposed to the light will continue to shine for some time after the light is removed. The existence of this power in some gems has been known for a long time, and is mentioned in some of the works of the ancients. Japanese antiquaries tell of a luminous stone that was dug out of the ground in A. D. 669.

The phosphorescent power of barium sulphide was discovered in 1675. Canton, in 1761, discovered the so-called phosphorus which bears his name by calcining oyster-shells with sulphur so as to form the calcium sulphide, the most remarkable of phosphorescent substances. Its luminosity appears to be permanent, for Professor Heaton, in a lecture describing the qualities of the luminous paint, delivered before the Society of Arts, on the 11th of March last, exhibited a specimen of it which had been sealed in glass by Canton himself in 1764, and which still glowed. The power is attributed to a property which the substances possessing it have of absorbing rays and afterward emitting them with an increased wave-length, as is remarkably shown by quinine, which shines after having been exposed to the ultra-violet part of the spectrum, and converts invisible actinic into visible light-rays. The late Mr. Balmain succeeded in producing from a compound of lime and sulphur a constant and very powerful phosphorescent substance, which he patented and applied as a paint; articles coated with it become luminous after exposure to the light and retain their glow for a considerable length of time. The sensitiveness of this substance was shown during Professor Heaton's lecture by passing electric sparks in front of a card painted with it which had been previously kept in darkness. Each spark impressed its image on the card, and made it luminous. Even a lucifer-match struck in front of a dark pane produced a visible effect on the paint. The highest effect is produced by the violet and ultra-violet rays. The red and yellow rays do not add to the luminosity; in fact, they diminish it when they are allowed to continue to act for a considerable time. This is owing to their calorific effect, which, though it may stimulate the light for a while, in the end causes it to disappear more rapidly. A short exposure of the paint to ordinary daylight is sufficient to produce a high degree of illumination, the amount and duration of which will depend considerably on the quantity and quality of the light and on other conditions. "When the paint has been exposed to the intense light of the sun or of burning magnesium, a good deal of the brilliancy disappears quickly, but after that the fading is very slow; and it may be said that a more or less useful light will remain through the length of an ordinary winter's night. In one case, Professor Heaton was just able to see the dial of a watch by the light emitted from a card which, after having been exposed to daylight of moderate intensity for two hours, had been in total darkness for twenty-six hours. The paint appears to be of satisfactory durability as against all weathers and the action of sea-water. The useful purposes to which it may be applied are almost innumerable. Clock-faces painted with it will show the time; match-boxes can be found, all through the night; the roofs of railway-cars will light passengers through tunnels; buoys in harbors and channels, and life-buoys, can be made visible; ships may show themselves to each other in the darkness; the diver, painting his dress with it, may be his own lantern and carry enough daylight with him to enable him to work under water at a considerable advantage. Its application to use in powder-magazines and coal-mines, and wherever fire-lights are dangerous, may be considered as among the things that are practicable. The manufacturers of the paint, Messrs. Ihlee & Horne, of Aldermanbury, London, say that it now costs twenty-eight shillings, or about seven dollars, a pound, and that a pound of it will paint about twenty-eight square feet. Two years ago they held it at five guineas a pound, but they have been able to lower the price gradually, and hope ultimately that it may be afforded at less than the cost of white-lead.

Is South America rising or sinking?—The question whether the South American Continent is sinking or not is one on which considerable difference of opinion still exists. Professor Orton several years ago expressed the belief that the barometric observations of the heights of the principal mountains, which have been continued through more than a hundred years, afforded evidence of a gradual sinking, and this opinion has prevailed extensively. Professor Agassiz believed that the eastern coast was sinking while the western coast was rising, and Darwin infers, from the discovery of the remains of an ancient civilization on lands that are now too high for the development of human life, that the land is rising. Dr. W. Weiss read a paper before the Berlin Geographical Society at a recent meeting, in which he advanced the theory, founded on a comparison of observations which had been made at the mouths of rivers, that the continent is rising. The Isthmus of Panama seems to be rising, and signs of elevation are apparent on the north coast of the continent. The delta of the Magdalena River has suffered notable changes within comparatively recent times. The tertiary highland of Turbaco, which extends from Carthagena to Sabanilla, was once an island in front of the stream, as is indicated by the forking of the river. One arm of the river empties toward the west near Carthagena, the other arm forms the present mouth with its branches in the lagoon of Santa Marta; ships formerly sailed into the western arm, which is not now navigable. The closing of this branch is generally ascribed to the luxuriant vegetation, but it is more than probable that other causes were combined with it. A small elevation would be enough to stop the flow of water, and the fact that such an elevation has taken place is shown by the discovery of recent shell-beds in a part of the lagoon. The bay of Santa Marta, with its monotonous sand-flats between steep, bald cliffs and island-like uprising knobs, produces the impression of a recently dried sea-bottom. Similar appearances are presented farther east, to such an extent that it was believed in the sixteenth century that the sea had retreated. The region of the lagoon of Maracaybo, and indeed the whole coast of Venezuela, appears to have taken part in a movement of uprising. The existence of the delta of the Orinoco favors the theory of elevation, for, though it can not be held that deltas are not formed except where the ground is rising, it is nevertheless true that elevation is most favorable to their formation. The observations along the coast of the British, French, and Dutch possessions are contradictory; but as a whole they seem to indicate that the land is gaining on the sea. The character of the changes that are taking place at the mouth of the Amazon is generally supposed to indicate a sinking of the land, but there are circumstances that favor the opposite view. The signs that the upper part of the bed of the river is rising are numerous, and all the phenomena of washing away at the mouth which are generally considered evidences of a depression can be accounted for by supposing that the interior is rising faster than the coast. Indications of a recent elevation may be seen all along the coast from Cape St. Roque to the La Plata, in the hardened shore-ridges of the Rio Grande do Norte, Parahyba, and Pernambuco, the elevated shore-lines of Rio Vermiglio, Bahia, and Rio Jequitinhonha, the coral reefs of the Abrolhos, the holes of the sea-urchin found above the level of the sea near Cape Frio, the new formations near Rio de Janeiro, the deterioration of the harbors of Santa Catarina, Porto Alegre, and other places. Darwin proved by the discovery of recent shell-deposits that the region of the La Plata was rising; since then some facts have been adduced pointing to a sinking, but the La Plata affords relations similar to those which have been referred to in the case of the Amazon. A lake in the Straits of Magellan containing marine animals, but situated at a higher level than that of the sea, is cited by Agassiz in proof that a rise of the land has taken place there. On the west coast signs of a sinking appear in the Chonos Archipelago, but they give way to trustworthy evidences of elevation in southern Chili. These continue to Callao and Lima, where a sinking is suddenly indicated. The land at Callao consists of gravel-beds, which may be considered as river and shore formations. Washings away from beneath, assisted by earthquakes, might readily have caused slight local falls, without making it necessary to invoke a sinking of the land. Not enough is known of the coasts north of Callao to justify a definite expression of opinion.

The Law of Mutual Help.—At the Congress of Russian Naturalists and Physicians, held in January last, Professor K. Kessler delivered an address on the law of mutual help, which he urged was entitled to a place by the side of Darwin's law of the struggle for existence. Having given a brief sketch of the theory of the struggle for existence, Professor Kessler remarked that it did not play the only part in organic development. By the operation of the reproductive instinct, there was developed in the different animal races a strong inclination for a closer association of the sexes, as well among individuals as in the whole group, under which the members of a society, of the whole species or family to which they belonged, were impelled to assist each other in the struggle for existence. He had observed numerous instances in which, after the death of the male, the female died, and conversely, or parents with the greatest self-denial sacrificed themselves for the protection of their young. All such examples showed that the reproductive instinct bound groups of related animals to each other through the law which he had enunciated. The principle was not limited to sexual association, but was exhibited wherever mutual help appeared to be necessary. As an example, the case was cited of a group of beetles which would combine their forces with severe exertion to drag away a dead mouse. Further, ants and bees illustrate the operation of the law in a high degree. The principle is developed with especial prominence in mankind. Only by the most powerful coöperation could men have succeeded in reaching the degree of civilization which the race has attained.

Iceland.—Mr. C. G. W. Lock, in a recent lecture before the British Society of Arts, on Iceland, mentioned that the island, so far from being small, as it is erroneously called, is considerably larger than Ireland or Ceylon. Its situation is such that its whole northern coast is shut in nearly every year by the descent of masses of ice from the north. The southern and western shores are affected by ice in very exceptional instances only. The country is essentially volcanic and mountainous; but Hecla, which monopolizes the geographical knowledge of most students on the subject, does not possess a single characteristic to place it above its fellows. The whole central plateau is a wild waste of lava and volcanic sand, and the only habitable parts of the island are a narrow fringe of coast land and a few of the larger river valleys. The great ridge of ice-clad hills, stretching across the island, acts as a refrigerator to the moisture-laden winds from the southwest, and produces two distinct climates: the northern, generally dry; and the southern, generally wet, and more temperate than the other. The fact that colonists from Great Britain participated in the settlement of Iceland more than a thousand years ago is attested by the identity of many words that are used by the people with British words. Ponies are the chief animal product of the island. From them the stocks of the "Black Country" of England are recruited. The sheep furnish a fine mutton, and a wool which is made up into excellent fabrics at home, or is exported. Profitable trades are driven in skins, catgut, fox-fur, and eider-down; the cod-fisheries are very important, and considerable trade is carried on in cod-liver oil and shark-oil. The salmon-fishery has been shamefully abused by the excessive employment of barbarous methods of taking the fish. It, however, is the one great attraction the island offers to sportsmen; and more profit might be gained, directly and indirectly, by letting out the streams, as in Norway, to English fly-fishers, than by contracting with fish-curers. The island was at one time well wooded, and supplied itself largely, if not entirely, with cereals, but the climate has deteriorated and the soil become sterile in consequence of the cutting away of the trees, and every grain of corn is now imported from Denmark. The principal mineral product is sulphur, which is deposited in a very finely divided state around the volcanic vents by the vapors issuing through them. It is the custom to describe the sulphur-mines of Sicily and the sulphur-mines of Iceland as somewhat similar, but for all practical considerations they are as distinct as a coal-seam and a forest. The Sicilian mines consist of deposits formed in past geological ages, now lying at great depths, and utterly devoid of reproductive power; the Icelandic beds are the work of to-day, lie on the very surface of the ground, and live and grow with unabated energy, replacing the deposit as fast as it is removed. The area comprised in the Icelandic sulphur districts collectively amounts to, perhaps, a dozen square miles. The sulphur forms a layer of varying thickness, covered by an earthy crust and underlaid by clays containing sulphur mixed with various acids and salts, and is invariably wet, in consequence of the steam condensed within it. The crystals are almost absolutely pure, but impurities are mechanically mixed with them. Other mineral products are gold and silver, which are found in minute quantities, Iceland-spar, pure specimens of which are valued for optical instruments and cabinets, coarse chalcedonies and zeolites, lignite, basalt, and volcanic products. The manufacturing industry of the country is confined to woolen fabrics, socks and stockings, gloves, and a homespun cloth, which are excellent.

The Eyesight of Readers.—A writer in the "Library Journal" calls attention to the danger which readers run of injuring their eyesight by the use of a bad light. He remarks that engravers, watchmakers, and all others who use the eyes constantly in their work, take extra care to preserve them by getting the best possible light by day, and using the best artificial light at night. The great army of readers are careless, and have, sooner or later, to pay the penalty of their carelessness by giving up night-work entirely, and sometimes reading, except at short intervals and under the best conditions. All departures from common type, making the matter more difficult for the eye to take in, increase the danger. The magnitude of the physical labor of reading is not appreciated. A book of five hundred pages, forty lines to the page and fifty letters to the line, contains a million letters, all of which the eye has to take in, identify, and combine each with its neighbor. Yet many readers will go through such a book in a day. The task is one he would shrink from if he should stop to measure it beforehand. The best positions and best lights, clear type, plain inks, with the best paper of yellowish tints, and abundant space between the lines, afford the best safeguards against harm.

What Vivisection has done for Man.—Dr. Charles Richet, in a vigorous defense of the practice of vivisection, demands that it shall be judged by its practical results, and claims that, if it can be shown that we have gained by that method of experiment the means of curing one or two diseases of man or of assuaging pain, it must be considered lawful. He cites a number of discoveries that have been made through vivisection to sustain his position. Among them is the discovery of the circulation of the blood. Galen established the fact that the arteries contained blood by observations in the artery of a living animal; Harvey opened the chests of living animals, cut into the pericardium, observed the contraction of the heart, and what was going on in the veins and arteries, and deduced from what he saw his theory of the circulation. Transfusion of blood, an operation resorted to in extreme cases with the best results in saving life, was introduced after its possibility had been ascertained from experiments upon animals first made in 1664 by Lower and afterward by Denis. "Experiment alone," Dr. Richet says, "will teach us precisely what quantity of blood is necessary and what is harmful; and if over-sensitiveness forbids animal suffering for this end, then the experiments would have to be made on human beings." The mode of death from the inhalation of carbonic oxide, and, correlatively, the method of avoiding or preventing death from inhalation, have been made known only through vivisection. So also "all that we know in hygiene of the quantity of air necessary to support life is the result of experiments on dogs and rabbits. Sometimes a precise knowledge of the conditions of respiration has served to prevent men from perishing." Only two methods exist by which we may learn the conditions of gastric digestion and collect its secretion, viz., by observation of gastric fistulæ produced by chance in man, and by artificial fistulæ in animals. The first method has been possible only in three or four instances, but the effect of food on the gastric secretion in dogs and cats has been largely observed; and the knowledge of the remedies which have been applied to the relief of dyspepsia has been derived from such studies. Our knowledge of nutrition has been largely added to by means of experiments in which dogs and cats have been submitted to varied alimentation, and from which the quantity and quality of food necessary to sustain life have been deduced. What we know of the nerves has been gained from studies of animals, as have also the means of relieving neuralgias and paralysis, in which, thanks to the scientific analyses of the vivisectors Fritsche, Hitzig, and Ferrier, "we can pass from the effect to the cause, and assign to paralysis a central lesion at a well-determined spot, so that trephining at this spot may cause the paralysis to disappear." The experiments of Galvani and his followers on frogs have taught us to estimate the effect of the electric current on nerve and muscle, and shown us how to apply galvanization to the prevention of the paralysis which ensues from the destruction of the motor nerves. The numerous patients relieved of nervous diseases "by this admirable therapeutic agent have no call to speak ill of such vivisectors as Galvani, Aldini, Volta, Magendie, Marshall Hall, Remak, Du-Bois Reymond, and many others, since it is to their discoveries that the relief of their ills is owing. Would Galvani have made his discoveries had he refrained from dissecting frogs? Would the electric current have been applied to atrophied limbs if it had not been found that the action of this current in dogs was salutary and not dangerous?" Certain diseases of the urinary organs have been studied in animals. The treatment of sympathetic ophthalmia by section of the ciliary nerves of the diseased side has been shown to be advantageous by experiment, and the results yielded by experiments on dogs and rabbits have been applied to patients. The correct treatment of cataract has been similarly learned. Encouraging progress is made by vivisection in the study of the formation of callus, of pseudarthrosis, of osseous grafts, of regeneration of bone by periosteum, subjects of great importance in surgery. The vaso-motor theory, which plays a large part in the medicine and surgery of the present day, has been established by experiments on the great sympathetic and the rabbit's ear. Dr. Brown-Séquard has furnished useful ideas relating to epilepsy and tetanus from the results of painful experiments on dogs and Guinea-pigs. Trial on animals is useful to determine the action of new medicines, for "we do not wish to experiment on man at the risk of poisoning him, where animals can be employed"; so with poisons. Finally, if we deprive *savants* of the right to submit living animals to experiment, we shall go back beyond the days of Galen. "If all those who have been relieved—verily made to live again"—says Dr. Richet, "by modern medicine and surgery, could speak, they would confound those who load vivisection with calumny, and they would hold that their own life and sufferings weighed more in the balance than the sufferings of those animals which have been sacrificed in laboratories to the lasting benefit of man."

Compression of the Feet of Chinese Women.—Miss Norwood, an American missionary at Swatow, has published a description of the processes employed to reduce the size of the feet of Chinese women. The binding of the feet is not begun until the child has learned to walk and to do certain other things which she could not well be taught to do afterward. The bandages employed are manufactured for the purpose, and are about two inches wide and two yards long for the first year, five yards long for the subsequent years. The end of the strip is laid on the inside of the foot at the instep, then carried over the top of the toes and under the foot, drawing the four toes with it down upon the sole; thence it is passed over the foot and around the heel; and by this stretch the toes and the heel are drawn together, leaving a bulge on the instep and a deep indentation in the sole under the instep. This course is pursued with successive layers of bandage, until the strip of cloth is all used, and the end is then sewed tightly down. The "indentation" should measure about an inch and a half from the part of the foot that rests on the ground up to the instep. The toes are drawn completely over the sole, and the foot is so squeezed upward that, in walking, only the ball of the great-toe touches the ground. Large quantities of powdered alum are used to prevent ulceration and lessen the offensive odor. At the end of the first month the foot is put into hot water, and, after it has been allowed to soak for some time, the bandage is carefully unwound, "the dead cuticle, of which there is much, being abraded during the process of unbinding." Ulcers and other sores are often found on the foot, and "frequently, too, a large piece of flesh sloughs off the sole, and it sometimes happens that one or two toes drop off." When this happens, the woman considers herself amply repaid for the additional suffering by having smaller and more delicate feet than her neighbors. Each time the bandage is taken off, the foot is kneaded, to make the joints more flexible, and is then bound up again as quickly as possible with a fresh bandage, which is drawn up more tightly. During the first year the pain is so intense that the sufferer can do nothing, and for about two years the foot aches continually, and has to endure besides a pain like the pricking of sharp needles. If the binding is kept up rigorously, the foot in two years becomes dead and ceases to ache, and the whole leg, from the knee downward, becomes shrunken to be little more than skin and bone. When once formed, the "golden lily," as the Chinese lady calls her delicate little foot, can never recover its original shape; and, when uncovered, it is so unsightly that women object to take off their bandages even before members of their own family.

A Volcano rising from a Lake.—M. de Lesseps has communicated some interesting papers on the extraordinary phenomena which accompanied the earthquakes of January last, in the republic of San Salvador, to which the French journals add accounts furnished by the consul of the republic and the French consul in Guatemala. The shocks, which, although of considerable strength, were not violent enough to do harm to houses, seemed to proceed from a center in the Lake of Ilopango or Cojutepeque. The waters of the lake having fallen from an extraordinary level to which they had risen before the shocks began, a small island with three peaks appeared to be rising from the center of the lake. One of the peaks reached a height of about ninety feet above the water, and sent forth a column of smoke and flames of considerable height. An attempt was made to approach the island in a boat, but the waters in contact with the hot rock were boiling, and gave out great jets of vapor. The water around the volcano continued to boil for some time after the eruption was over, and indicated a temperature of 100° at the edges of the lake. The fish were cooked and rose to the surface, and with them many shells and aquatic animals. The lake is in the line of the volcanoes of Central America, where volcanic cones seem to alternate with lakes, and itself occupies the place of an ancient volcano. Its water is brackish, bitter, and almost slimy, and has at times given out bubbles of sulphuretted gas. The rise of the water preceding the eruption agrees curiously with an ancient tradition that earthquakes may be expected whenever the level of the lake is elevated. So fully was this believed that the people were formerly accustomed to dig channels to carry off the superfluous waters; and while they did this they had no earthquakes. These facts have a bearing upon the theory that earthquakes and volcanic phenomena are largely due to the action of water.

Volcanic Eruptions and Earthquakes in 1879.—According to Herr Fuchs, only three volcanic eruptions took place in 1879, none of which were of extraordinary violence. The most notable one was that coincident with the appearance of a new volcano in Lake Ilopango, in San Salvador, following on a series of earthquakes in December. The eruption of Etna, which began on the 26th of May and lasted for eleven days, was especially marked by an uncommonly long lava-stream—of sixteen kilometres, or ten miles. The preceding earthquakes were not very strong. The third eruption was that of the volcano Merapi, in Java, on the 28th of March, which was marked by an abundance of lava and ashes. Only a few of the ninety-nine earthquakes which came to the knowledge of Herr Fuchs were of remarkable strength. A violent earthquake was felt in northern Persia for several hours on the night of the 22d of March, and destroyed a number of villages. About nine hundred persons perished between that date and the 2d of April, when the last vibrations occurred. Earthquakes of unusual strength occurred in the Romagna (Italy) on the 25th of April, and in Mexico on the 17th of May. In the latter earthquake the movement of the ground was observed in all the region from Vera Cruz to the capital, and much injury was done in Cordoba and Orizaba. Violent earthquakes began in a part of China on the 29th of June, extended over thirty districts, and the shocks were repeated till the middle of August, with the loss of many hundred lives. These earthquakes were marked by great jets of water spouting up through the opened ground.

Several other earthquakes of the year were accompanied by the phenomena of fountains, as in Bessarabia in May, and one on the lower Danube in October. Earthquakes occurred at nine different points in the German Empire on thirteen days. The days on which the most earthquakes were noticed were the 14th of February and the 2d of July.

Relation of the Algæ to the Phanerogams.—Dr. Ernst Krause in a late number of "Kosmos" has a discussion of the relationship between the algæ and the phanerogams, taking the *Podostemaceæ* as the special subject of his dissertation. The species of this family, he believes, combine characteristics of the algæ and phanerogams, and show a direct transition between them, as in the opinion of many botanists the *Cytineæ* and *Balanophoreæ* do between the fungi and the phanerogams. The resemblance between the two families is so striking, and the forms of both so variable, that one would be excusable for inferring that the podostemes are algæ with phanerogamous flowers; their flowers are, moreover, either apetalous or imperfect, and very simple. They are described by H. A. Weddel as very small plants, which cling to rocks overflowed by running water in the tropical regions of Asia, Africa, and America. The lower forms are composed of little else than parenchyma, while only the larger ones have vascular organs. The stem is either wanting or assumes an extreme diversity of shapes; sometimes it is upright and dichotomous, branched and leafy; sometimes it is like certain mosses; often it is spread on the ground, or attached with a cushion-like foot; sometimes it creeps like a rhizoma or is leaf-like, like the thallus of some liverworts or lichens, and clinging to the stone in the same manner as they do. It has hardly any true roots. Leaves are for the most part absent in the thallus-like species, but are highly diversified in the stemmed species, departing at the same time widely from the ordinary forms; they are seldom square on the stalk, are entire or unequally divided, often forked. The nerves, when they exist, are dichotomous, seldom parallel. The buds, both of the stem and the flowers, are folded convolutely. The cushion-like organs of attachment are elsewwhere found only among the algæ; the absence of vascular organs is common to algæ and mosses among green plants, and also to a few phanerogams, as the *Naiadeæ*, *Ceratophylleæ*, and *Lemnaceæ*. As the lower plants of these orders show no differentiation of stem and leaf, at least no more than the algæ, they might be placed, with the *Podostemaceæ* in a group representing a direct transition between the algæ and the phanerogams, for which the provisional name of *Anthophyceæ* is suggested. If we also regard the *Cytineæ*, which have no cotyledon, and the *Balanophoreæ*, which have only a simple undivided embryo, as higher forms rising out of the fungi, we may join them as *Anthomycetæ* with the *Anthophyceæ* representing the lowest phanerogams, as *Anthothalloidæ*.

Chimborazo and its Climbers.—Referring to the successful attempt of Mr. Whymper to ascend to the summit of Chimborazo, Dr. Nachtigal stated, at a recent meeting of the Berlin Geographical Society, that a Frenchman, Jules Remy, professed to have accomplished the feat in 1856, but it is very doubtful if he did. He gave the height at 7,328 metres (23,816 feet), whereas it is 1,000 metres, or 3,250 feet less. Humboldt observed the height trigonometrically to be 6,530 metres (or 21,222 feet), and Reiss, as the result of three measurements, found the highest of the two peaks to be 6,310 metres (20,507 feet) and the other 6,269 metres (20,374 feet). Humboldt, in 1802, attempted the ascent, but only reached a height of 5,878 metres (19,103 feet), while Boussingault, with Hall, in 1831, reached a height of 6,004 metres (19,513 feet); they attempted the ascent from the south side, while Dr. Stuhel, from the north side, reached a height of 5,810 metres (18,882 feet). After an inspection of ten days, Mr. Whymper made three attempts, and on the third day succeeded in mounting both peaks. The night before the final ascent he spent at a height of 5,227 metres (16,988 feet).

The Comets of 1843 and 1880.—It seems to be well established that the comet which recently appeared in the southern hemisphere is identical with the great comet of March, 1843. This comet, one of the most remarkable in history, appears to have been first seen by Captain Ray, an American sailor, at Concepcion, South America, at about noon of February 27th, only a short distance in the sky from the sun. On the 28th of February, the head of the comet, with a tail several degrees in length, was observed at noon in various parts of Italy, off the Cape of Good Hope, and at different points in the United States and Mexico. The tail was remarked on the 1st of March in southern latitudes, on the 8th at Lisbon, Portugal, and on the 11th at Montpellier, France, but was not observed in England till the 17th, on the evening of which day it attracted general attention in most parts of Europe.

Hygiene of New-born Children.—The subject of the hygiene of new-born children is engaging the attention of French sanitarians. The present minimum rate of mortality of children under one year old is estimated to be one hundred per thousand. The rate in France is double this, or two hundred per thousand; and the excess is really greater than it seems, for the minimum itself is larger than it should be, and ought, by proper management, to be reduced to eighty and even seventy in a thousand. The chief among the several causes to which the large proportion of deaths is ascribed is artificial alimentation. That the whole physiological development of the new-born child is determined by the character of the food that is given to it, is enforced by all the facts that have been gathered in France. The subject was fully discussed at the International Hygienic Congress, held at Paris during the Exposition of 1878, and some significant facts were presented in illustration of the enormous difference which exists between the mortality of children brought up at home and that of children intrusted to hired nurses and the not less marked difference in the rate of mortality of children nursed at the breast and of children fed artificially. Among children of the easier classes, brought up at home, the rate of mortality often falls as low as 70 or 80 per 1,000; among children intrusted to hired nurses, it was stated to vary from 240 to 750, and even to 900 per 1,000. Among children nursed by their mothers, a rate of mortality was found of only 8·28 per 100; among children brought up by nurses, of 18 per 100 at home, 22 per 100 when they were taken away; among those fed from the bottle, the average was 51 per 100. Dr. Monot stated that, in the department of the Nièvre, in the case of children who had been sent down from Paris without supervision, and had been consigned to hired nurses, the mortality was 710 per 1,000. In the case of assisted children sent out by responsible organizations, under the care of agents and inspectors, it was 240 per 1,000; in the case of those intrusted to nurses who were watched over by the societies for the protection of infants, it fell to 120 and even 90 per 1,000; and, in cases where the young mothers were helped to the means of living, and were able to take care of their children and nurse them, to 70 per 1,000. These facts, though many of them are only approximative, seem to be decisive as to the superiority of maternal nursing. Inasmuch, however, as the number of mothers who can not themselves nurse their babies is very great, and a large proportion of them are not able to hire wet-nurses, the question as to what is the best substitute for mother's milk is an important one. The Municipal Council of Paris has just authorized an experiment which will help answer it. It has decided to establish a nursery in connection with its hospital for assisted children, with stables to be occupied by the various animals usually depended upon for their milk, the milk of which will be given to the children fresh and absolutely pure, in such a systematic manner that the advantages attributed to the milk of each animal may be rigorously and scientifically tested. The whole will be under the direction of Professor Parrot.

Equatorial Temperatures.—Why is the equator not warmer in January, when the earth is nearest to the sun, than in July? Mr. Croll assigns as the reason that the northern hemisphere, which he calls the dominant hemisphere, having its winter in January, the whole earth is colder at that time; also that the northern trade-winds pass farther south in January, and cool the equatorial regions more than at the other seasons. His views are disputed by Mr. A. Woickoff, of St. Petersburg, who denies that the winds and condition of the northern hemisphere have any perceptible influence at the equator, and ascribes the mildness and uniformity of the equatorial temperature to the prevalence of the rainy season in our winter, the southern summer months. Water acts during this season to reduce the temperature through its great capacity for heat, through the screen of clouds which it interposes between the sun and the surface of the earth, and through evaporation, and this upon the higher as well as upon the lower strata of air. It is admitted that winds have some effect as aids to the cooling, but the insignificance of their influence, as against any active heat-producing force, and in the absence of moisture, is shown by the fact that the Sahara is the hottest region in the world, notwithstanding the winds that blow over it from the cool Mediterranean.

Messages by Heliograph.—The usefulness of the heliograph was recently satisfactorily tested in the transmission of a dispatch from General Stewart, in Afghanistan, announcing the result of an attack on the British troops, which was sent from Camp Ghuzni, April 22d, and was received at the India Office, London, on the following day. The news could hardly have been brought more speedily by electric telegraph. The heliograph, signaling right over the heads of the enemy, if necessary, to stations which may be few and far between, does not require any route to be kept open, and can not be interrupted. A ten-inch mirror, that being the size of the ordinary field-heliograph, is capable of reflecting the sun's rays in the form of a bright spot to a distance of fifty miles, where the signal can be seen without the aid of a glass. The adjustment of the instrument is very simple. If an army corps, having left its base where a heliograph station is established, desires to communicate with the other division from a distance of several miles, a hill is chosen and a sapper goes upon it with his heliograph-stand containing a mirror swung so as to move horizontally and vertically. A little of the quicksilver having been removed from behind the center of the mirror, a clear spot is made through which the sapper can look from behind his instrument toward the station he desires to signal. Having sighted the station by adjusting the mirror, he next proceeds to set up in front of the heliograph a rod on which is a movable stud, manipulated like the foresight of a rifle. The sapper, standing behind his instrument, directs the adjustment of this stud until the clear spot in the mirror, the stud, and the distant station are in a line. The heliograph is then ready to work, and the sapper has only to take care that his mirror reflects the sunshine on the stud just in front of him to be able to flash signals so that they may be seen at a distance.

Ocean Temperatures in the Pacific and Atlantic.—Herr von Boguslawski has been led, from a comparison of the results of recent deep-sea investigations, to the following conclusions respecting the temperatures of the Atlantic and Pacific Oceans: 1. The water of the North Pacific is, in its whole mass, colder than that of the North Atlantic. 2. The water of the South Pacific is, down to 1,300 metres (4,225 feet), somewhat warmer than that of the South Atlantic, but below this depth colder. 3. The bottom temperatures are generally lower in the Pacific than in the Atlantic at the same depths and in the same degree of latitude; but nowhere in the Pacific are found such low bottom temperatures as in the Antarctic portion of the South Atlantic, between 36° and 38° south and 48° and 33° west longitude, in which bottom temperatures of −0·3° C. to −0·6 C. have been measured. 4. In the western parts of the Pacific, and the adjoining parts of the East Indian Archipelago, the temperature of the water reaches its minimum at depths beween 550 and 2,750 metres (1,787 and 8,937 feet), remaining the same from this depth to the bottom. In the whole of the Atlantic the temperature from 2,750 metres (8,937 feet) to the bottom gradually though very slowly decreases.

The Harvard Medical Course.—Professor James C. White, of the Medical School of Harvard University, states that the enlargement of the course of instruction which was adopted by the department ten years ago has been followed by a general elevation of the standard of medical education throughout the country, and has been attended by great advantages to the Harvard school. The classes have grown constantly larger, and the quality of the students has improved in nearly the same degree. An admission examination was instituted soon after the new course was adopted, and has recently been made considerably more efficient. The faculty now find that the three years which are allotted to the course are not enough to permit a thorough mastery of all the branches which it embraces, and contemplate adding a fourth year. For the present, the additional year will be optional with the student, who may either crowd all he can into three years as before, or take more time for what has hitherto been attempted in that period, and pursue the special studies which are additionally provided for the fourth year. In the schedule of studies under the new arrangement the main studies of the third year are continued into the fourth year, and an examination will be held at the end of the latter year in a number of special branches, the instruction in which is intended to be more clinical and individual in character than that heretofore given and to take the place partly of the private teaching which American students have heretofore sought in European schools after graduation.

The Cutting Ant.—The Rev. H. C. McCook, of Philadelphia, has made a very interesting study of the cutting or parasol ant (*Atta fervens*, Say), having encamped for the purpose close by its haunts near Austin, Texas. The habitation of the insect was marked by a bed of denuded earth on the prairie, measuring in the case of the one specially examined eight feet nine inches by about seven feet. Over this denuded surface were scattered between twenty and thirty circular, semicircular, and S-shaped elevations of fresh earth-pellets, the circular ones resembling a spittoon three or four inches high, which had apparently been formed by the accumulation of the pellets of sandy soil as they were brought out and dumped upon the circumference of the heap. No life was noticed around the colony during the day, but earthen knobs or warts, and small, irregular heaps of dry leaves, bits of leaves and twigs were noticed scattered over the surface. As evening began, the scene was wholly changed. "Hosts of ants of various sizes, and in countless numbers, were hurrying out of open gates into the neighboring jungle, and two long, double columns were stretched from the bottom to the top of the large overhanging live oak. The ants in the descending columns all carried above their heads portions of green leaves, which waved two and fro and glanced in the lantern-light, giving to the moving column a weird look as it moved along. It seemed like a procession of Liliputian Sabbath-school children bearing aloft their banners. It is this habit which has given this insect in some quarters the popular name of the 'parasol ant.' It is also called in Texas the 'Brazilian ant,' but is quite universally known as the 'cutting ant,' certainly a most appropriate name." The heaps of leaves and twigs lying around the habitation were the closed gates. The opening and closing of these gates occurred before and after every exit from the nest. The process was a long, careful, and complicated one, the opening beginning toward evening, and the closing ending in the morning, sometimes as late as half-past ten. Toward dusk, the minims, or smallest ants, would appear, taking away from the heap particles of sand; larger forms followed carrying away bits of refuse, which they dropped at about two inches from the gate. Finally, the throng would rush out, bearing before them the rubbish, which after a few moments was cleared away from the gallery and spread around the margin of the gate. The litter thus taken away was brought into use again when the gates were closed. In closing the gates, the larger forms did their work first, bringing in twigs, some as long as an inch and a half, and dried leaves, which they deposited to the depth of from a half-inch to an inch and a half below the surface. As the hole was gradually closed, only the smaller forms appeared, and the last touches were carefully and delicately made by the minims, which filled in the remaining interstices with minute grains of sand. A division of labor was noticed in the work of cutting and carrying the leaves. The party consisted of soldier-ants, seeming to act as escort and scouts, the cutters, and the carriers, who took the cut leaves from the base of the tree and bore them to the nest. This work was not given to the smaller castes. The leaves principally gathered were those of the live-oak. The ants seemed to prefer trees with a smooth leaf, were severe upon grapes, peaches, the China tree, and radishes, took many other garden vegetables and plants, and loved sugar, grain, and tobacco. The interior of the formicary, as carefully examined by Mr. McCook, seemed to consist of an irregular arrangement of caverns of various sizes, communicating with the surface and with each other by tubular galleries. Within the chambers were masses of very light, delicate leaf paper, wrought into a honeycomb-like fabric, hemispherical, columnar, or hanging, composed of cells of various sizes, generally hexagonal in shape, the material of which crumbled under even delicate handling. Large numbers of ants, chiefly of the smaller castes, were found in these cells. Ten distinct castes or sizes of ants were measured, the largest being seven eighths and the smallest one sixteenth of an inch long. Several holes in the vicinity of Austin were visited, out of which nests of ants had been dug. They were nearly as large as a cellar for a small house, one measuring twelve feet in diameter and fifteen feet deep, and the main cavity being as large as a flour-barrel.

The Aborigines of Botel Tobago.—Dr. Charles A. Siegfried, of the United States Navy, in a letter which has been read before the Philadelphia Academy of Sciences, describes a visit he made in December, 1878, to an island called Botel Tobago, about eighty miles east of the south cape of Formosa. He found there a race of aborigines, supposed to be from Malay stock, who knew nothing of money, rum, or tobacco, but who gave goats and pigs for tin pots and brass buttons, and would hang around the ship all day in their canoes, waiting for a chance to dive for something thrown overboard. They wore clouts only, and lived mainly on taro and yams, though they had also pigs, goats, chickens, fish, and cocoanuts. Their thatch houses were low, with overhanging roofs, and surrounded by stone walls strongly made of laid stone to protect them from monsoons. They were peaceful and timid, did not mark the body or deform the face or teeth, and seemed happy enough in their condition, and fairly healthy. They wore their hair naturally, the men partly clipping theirs, and adorned their necks with the beards of goats and small shells. They had axes, spears, and knives, but all of common iron, and their axe was inserted in the handle, instead of the handle being inserted in the axe, as with us. Their canoes were beautiful, made without nails, and usually ornamented with geometrical lines.

Asphalte and Amber in the Mud of New Jersey.—The "Proceedings" of the Academy of Natural Sciences of Philadelphia contain a description of a mass of asphaltum, weighing about a hundred pounds, which was found near Vincenttown, New Jersey, in the ash-mud, a layer above the green-sand proper, about sixteen feet below the surface. It is the first specimen of this peculiar kind of hydrocarbon that is known to have been observed in New Jersey. It is very brittle, black, with a resinous luster, uneven fracture, inclined to conchoidal, melts easily, and burns with a yellow, smoky flame, leaving a voluminous coal and but little ash. It is soluble in chloroform and oil of turpentine, in ether with difficulty; insoluble in alcohol, water, and solution of caustic potassa. Oil of vitriol dissolves it into a black liquor, of which a part is retained in solution in water, a part subsides as a dark-colored powder. Nitric acid reacts upon it at an elevated temperature, forming with it soluble products of oxidation. Near the pit from which the asphaltum was obtained, a specimen was found of a yellow mineral resin, which occurs frequently, but not regularly, in the mud of the cretaceous formation. It is usually called amber, or succinite, but differs from the typical amber of the Baltic in being lighter than water, fusing into a very fluid, mobile liquid, and in having a less strong cohesion, qualities which indicate its analogy to the variety of succinite called krantzite. It burns easily, with a yellowish, strongly smoking flame, leaving but little coal; it may be vaporized into a gray cloud of strongly penetrating odor, which condenses into an oily liquid, and some crystals. It is freely soluble in chloroform, bisulphide of carbon, and oil of turpentine, sparingly soluble in water, alcohol, and ether, and is partly dissolved by caustic potassa. Cold nitric acid affects it but little. Oil of vitriol makes with it a red solution. The yellowish powder becomes orange-red on warming.

NOTES.

Professor William Lee, M. D., of Washington, is the author of the article entitled "The Extreme Rarity of Premature Burials," published in the August "Monthly." The misspelling of the name was an editorial blunder, for which we beg to apologize both to Dr. Lee and to our readers.

M. Toussaint has been investigating the question of the transmission of tubercle, by means of experiments on the hog. He caused animals to eat the lungs of tuberculous sheep, and tried inoculation by the blood and by milk, and found that the animals became diseased in every case. Similar effects were produced upon healthy animals which lived with tuberculous ones.

The production of nickel has assumed great importance in Norway within a few years. Eleven mines had been opened between 1861 and 1865, which yielded an average of 3,450 tons a year. In 1875 fourteen mines had been opened, which furnished a maximum of 34,500 tons. The larger part of the yield is exported in the condition of ore, the rest is reduced on the spot.

The fiftieth annual meeting of the British Association for the Advancement of Science will begin at Swansea, August 25th. Dr. Andrew Crombie Ramsey, Director-General of the Geological Survey of the United Kingdom and of the Museum of Practical Geology, will preside and deliver the opening address. The secretaries are Captain Douglas Galton, F. R. S., and Philip Lutley Sclater, Ph. D., F. R. S., general secretaries, and J. E. H. Gordon, assistant secretary.

The Swiss Natural History Society will hold its general meeting from the 12th to the 15th of September, at Brieg, in the Canton Vaud.

The death of Mr. Alfred Swaine Taylor, a well-known English physician and toxicologist, is announced. He was born in 1806, studied in the leading medical schools at home and abroad, was the first holder of the chair of Medical Jurisprudence in Guy's Hospital, and was the author of several professional treatises, especially on the subjects of poisons and poisoning, chemistry, and medical jurisprudence.

The French Association for the Advancement of Science holds its meeting for this year at Rheims, August 12th to 19th. An exposition of local industry and archæology, and excursions, the most notable of which is to the Han Grottoes, in Belgium, are arranged for in connection with the meeting.

A committee was appointed in 1876 by the Academy of Natural Sciences of Philadelphia, at the request of the Centennial Commission, to report upon the subject of the insects and plants that might be introduced to our soil through the medium of foreign exhibits. The report upon plants has been delayed till this year in order that, by taking several seasons for the examination, the committee might be sure that no species escaped them. They now announce that they have found in the Exhibition grounds plants of but thirteen species, and those only in isolated specimens showing no disposition to spread. Some of the species are from the western part of our country, some from Europe, and a few from Japan.

Professor Christian August Friedrich Peters, of Kiel, editor of the "Astronomische Nachrichten," died May 8th, after an illness of several months. He was born in Hamburg in 1806; was appointed an assistant in the observatory at Hamburg in 1834; to the Russian observatory at Pulkowa, where he remained for ten years, in 1839; was named Professor of Astronomy in the University of Königsberg in 1849; and director of the observatory at Altona, which was afterward removed to Kiel, in 1854. His most important memoirs were on "Nutation," on "The Parallax of the Fixed Stars," and on the "Proper Motion of Sirius."

Professor W. H. Miller, of the University of Cambridge, died May 20th, in his eightieth year. He succeeded Dr. Whewell as Professor of Mineralogy in 1832, and published his treatise on "Crystallography," a work which was almost universally accepted as a standard, in 1838. His "Manual of Mineralogy" appeared in 1854, and was full of the results of his own research. He was the author of several other books and memoirs.

At a show of birds lately held in Berlin, several canaries were exhibited that attracted much attention on account of the peculiar colors of their plumage. Some were green, others red and light brown, and others of a soft gray tint, while all differed more or less from the light yellow of the common bird. These variations of color were produced by the daily use of cayenne pepper in the food of the birds. The pepper is given in small quantities at first, and the birds appear to like it, but the immediate effects are anything but pleasing to the beholder. The feathers soon begin to fall, giving the bird very much the appearance of molting; in a short time, however, new feathers make their appearance, and it is then, as they attain full growth, that they exhibit the curious tints observed.

Professor C. W. Claypole, of Antioch College, Ohio, has recently been examining the Schliemann collection of antiquities in the South Kensington Museum in London, and he concludes that the names attached to some of the objects in the collection betray a rather unwarrantable use of the imagination. Among others, the little hour-glass-shaped pebbles labeled "Minerva Ornaments," and hitherto regarded as idols, are in his opinion nothing more than "Trojan net-sinkers," being almost identical in form and appearance with the "net-sinkers" frequently found on the shores of our lakes and rivers.

Dr. James Prescott Joule has received the Albert Medal from the Society of Arts, for having, as the award reads, established, after most laborious research, the true relation between heat, electricity, and mechanical work.

Dr. Paul Broca, the distinguished French anthropologist, was taken ill at the session of the French Senate of July 8th, and died the following night. He was fifty-six years old, and had lately been elected a life-member of the Senate.

Holland has lost its leading chemist by the death of Professor G. J. Mulder, of Utrecht, which took place in May last. Professor Mulder was born in 1802, and, previous to taking the chair of Chemistry at Utrecht in 1841, served as Professor of Botany and Chemistry at the Rotterdam Medical School. He made a variety of researches and discoveries in the chemistry of vegetable physiology, and in animal chemistry proved the presence of carbonic acid as a normal constituent of the blood. He was the author of numerous works, and the editor from 1842 to the time of his death of the only chemical journal of Holland.

M. Camille Flammarion has been awarded the Monthyon prize of the Paris Academy of Sciences for his new work on "Popular Astronomy" ("Astronomie Populaire").

Letters recently received in England from Mr. Whymper state that he has found very extensive glaciers on the mountains Cayambe, Sarauscu, and Cotocachi, and had previously discovered other glaciers on Chimborazo, Sincholagua, Antisana, Cotopaxi, Iliniza, Carihuairazo, and Quilindaña. Many of these glaciers are as large as the largest Alpine ones, and the upper four thousand feet of Cayambe, Antisana, and Chimborazo are almost completely enveloped by them. Mr. Whymper is contributing largely to our knowledge of these mountains, for the last edition of the "Encyclopædia Britannica" mentions the glacier of the mountain Altar as the only real glacier known to exist in the Ecuadorian Andes.

The entire absence of scurvy during the voyage of the Vega is attributed by Professor Nordenskjöld to the free use of a little berry that springs out of the ice and snow during the summer. It bears profusely, and has a taste like the raspberry, but more acid. The fruit is dried and mixed with the milk of the reindeer, and can be carried in a frozen state for thousands of miles. It appears also that the party were never wholly without daylight, having two hours of it during the shortest day, although the sun was not above the horizon.

The Custos of the Berlin Agricultural Museum, Dr. L. Wittmacht, has lately been engaged in the examination of some partly carbonized seeds which were found by Virchow and Schliemann in their excavations. Among them were a vetch (*Ervum Ervilia*, L.), field-beans, and peas. The discovery of the peas is the more interesting because, according to several authors, peas were unknown to the ancient Greeks. A remarkable seed was a hard wheat, extremely small grained, very sharp, closely pressed, extraordinarily flat on the furrowed side. The grains are wholly different from those of every wheat hitherto known, and are especially distinct from the thick-bellied grains of the Egyptian mummy-pits and of the lake-villages.

A practical test of the efficiency of the electric light in naval operations was made recently on board two vessels of the British navy at Gibraltar. During the practice, which was continued for nearly an hour, every hole and cranny on the western face of the rock was searched out and illuminated with the clearest distinctness, and every boat and vessel in the bay underwent a similar minute examination. Only a limited surface could, however, be illuminated at a time, so that the process of search was somewhat slow.

M. Boiteau has reported to the French Academy of Sciences that the application of sulphide of carbon as a cure for the phylloxera has proved thoroughly successful. Diseased vines, which were treated with this substance two or three years ago, look even better now than they did before they were attacked; and it seems established that the sulphide has no damaging effect on the productiveness of the soil. The only drawback to the use of the substance is its scarcity and consequent high price.

GEORGE BOOLE.

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FASHION IN DEFORMITY.*

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I HAVE to ask your attention this evening to certain outward manifestations of a propensity common to human nature in every aspect in which we are acquainted with it—the most primitive and barbarous, and the most civilized and refined—but one which is, as far as I know, peculiar to human nature.

I shall speak of *deformity* in the sense of alteration of the natural form of any part of the body, and those cases of voluntary deformation will be considered which are performed, not by isolated individuals, or with special motives, but by considerable numbers of members of a community in imitation of one another—in fact, according to *fashion*, "that most inexorable tyrant, to which the greater part of mankind are willing slaves."

Fashion is now often associated with change, but in more primitive communities fashions of all sorts are more permanent than with us; and in all communities such fashions as those I am now speaking of are, for obvious reasons, far less likely to be subject to the fluctuations of caprice than those affecting the dress only, which, even in Shakespeare's time, changed so often that "the fashion wears out more apparel than the man." Alterations once made in the form of the body can not be discarded or modified in the lifetime of the individual, and therefore, as fashion is intrinsically imitative, such alterations have the strongest possible tendency to be reproduced generation after generation.

The origins of these fashions are mostly lost in obscurity, all

* A discourse delivered at the Royal Institution, Friday, May 7, 1880.

attempts to solve them being little more than guesses. Some of them have become associated with religious or superstitious observances, and so have been spread and perpetuated; some have been vaguely thought to be hygienic in motive; most have some relation to conventional standards of improved personal appearance; but, whatever their origin, the desire to conform to common usage, and not to appear singular, is the prevailing motive which leads to their continuance.

The most convenient classification of these customs will be one which is based upon the part of the body affected by them, and I will begin with the more superficial and comparatively trivial—the treatment of the hair and other appendages of the skin.

Fig 1.—Australian Native, with Bone Nose-Ornament.

Here we are at once introduced to the domain of Fashion in her most potent sway. The facility with which hair lends itself to various methods of treatment has been a temptation too great to resist in all known conditions of civilization. Innumerable variations of custom exist in different parts of the world, and marked changes in at least all more or less civilized communities have characterized successive epochs of history. Not only the length and method of arrangement, but even the color of the hair, is changed in obedience to caprices of fashion. In many of the islands of the Western Pacific, the naturally jet-black hair of the natives is converted into a tawny brown by the application of lime, obtained by burning the coral found so abundantly on their shores; and, not many years since, similar means were employed for producing the same result among the ladies of Western Europe—a fact which considerably diminishes the value of an idea entertained by many ethnologists, that community of custom is evidence of community of origin or of race.

Notwithstanding the painful and laborious nature of the process, when conducted with no better implements than flint knives, or pieces of splintered bone or shell, the custom of keeping the head closely shaved prevails extensively among savage nations. This, doubtless, tends to cleanliness, and perhaps comfort, in hot countries; but the fact that it is in many tribes practiced only by the women and children shows that these considerations are not those primarily engaged in its perpetuation. In some cases, as among the Feejeeans, while the heads of the women are commonly cropped or closely shaved, the men cultivate, at great expense of time and attention, a luxuriant and elaborately arranged mass of hair, exactly reversing the conditions met with in the most highly civilized nations.

In some regions of Africa it is considered necessary to female beauty carefully to eradicate the eyebrows, special pincers for the purpose forming part of the appliances of the toilet; while the various methods of shaving and cutting the beard among men of all nations are too well known to require more than a passing notice. The treatment of finger-nails, both as to color and form, has also been subject to fashion; but the practical inconveniences attending the inordinate length to which these are permitted to grow in some parts of the east of Asia appear to have restricted the custom to a few localities.

If time allowed, the exceedingly widespread custom of tattooing the skin might be here considered, as a result of the same propensity as that which produces the other more serious deformations, now to be spoken of; but it will be as well to pass at once to these.

The nose, the lips, and the ears have, in almost all races, offered great temptations to be used as foundations for the display of ornament, some process of boring, cutting, or alteration of form being necessary to render them fit for the purpose. When Captain Cook, exactly one hundred years ago, was describing the naked savages of the east coast of Australia,* he said: "Their principal ornament is the bone which they thrust through the cartilage which divides the nostrils from each other. What perversion of taste could make them think this a decoration, or what could prompt them, before they had worn it or seen it worn, to suffer the pain and inconvenience that must of necessity attend it, is perhaps beyond the power of human sagacity to determine. As this bone is as thick as a man's finger, and between five and six inches long, it reaches quite across the face, and so effectually stops up both the nostrils that they are forced to keep their mouths wide open for breath, and snuffle so when they attempt to speak that they are scarcely intelligible even to each other. Our seamen, with some humor, called it their spritsail-yard; and, indeed, it

* "First Voyage," vol. ii., p. 633.

had so ludicrous an appearance that, till we were used to it, we found it difficult to refrain from laughter."

Eight years later, on his visit to the northwest coast of America, Captain Cook found precisely the same custom prevailing among the natives of Prince William's Sound, whose mode of life was in most other respects quite dissimilar to that of the Australians, and who belong ethnologically to a totally different branch of the human race.

In 1681 Dampier * thus describes a custom which he found existing among the natives of the Corn Islands, off the Mosquito coast, in Central America: "They have a Fashion to cut Holes in the Lips of the Boys when they are young, close to their Chin, which they keep open with little Pegs till they are fourteen or fifteen years old; then they wear Beards in them, made of Turtle or Tortoise-shell, in the Form you see in the Margin. The little Knotch at the upper end they put in through the Lip, where it remains between the Teeth and the Lip; the under Part hangs down over their Chin. This they commonly wear all day, and when they sleep they take it out. They have likewise Holes bored in their Ears, both Men and Women, when young, and by continual stretching them with great Pegs, they grow to be as big as a mill'd Five-shilling Piece. Herein they wear Pieces of Wood, cut very round and smooth, so that their Ear seems to be all Wood, with a little Skin about it."

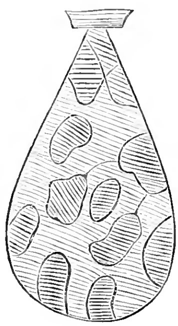


FIG. 2.

It is a remarkable thing that an almost exactly similar custom still prevails among a tribe of Indians inhabiting the southern part of Brazil—the Botocudos, so called from a Portuguese word meaning a plug or stopper. Among these people the lip-ornament consists of a conical piece of hard and polished wood, frequently weighs a quarter of a pound, and drags down, elongates, and everts the lower lip, so as to expose the gums and teeth, in a manner which to our taste is hideous, but with them is considered an essential adjunct to an attractive and correct appearance.

In the extreme north of America, the Esquimaux "pierce the lower lip under one to both corners of the mouth, and insert in each aperture a double-headed sleeve-button or dumb-bell-shaped labret, of bone, ivory, shell, stone, glass, or wood. The incision when first made is about the size of a quill, but, as the aspirant for improved beauty grows older, the size of the orifice is enlarged until it reaches the width of half to three quarters of an inch." † These operations appear to be practised only on the men, and are supposed to possess some significance other than that of mere ornament. The first piercing of the lip,

* "Voyage Round the World," edition 1717, vol. i., p. 32.

† H. H. Bancroft, "Native Races of the Pacific States of North America," vol. i., 1875.

which is accompanied by some solemnity as a religious feast, is performed on approaching manhood.

But the people who have carried these strange customs to the greatest excess are the Thlinkeets, who inhabit the southeastern shores of Alaska.* "Here it is the women who, in piercing the nose and ears, and filling the apertures with bones, shells, sticks, pieces of copper, nails, or attaching thereto heavy pendants, which drag down the organs and pull the features out of place, appear to have taxed their inventive powers to the utmost, and with a success unsurpassed by any nation

FIG. 3.—BOTOCUDO INDIAN. From Bigg-Wither's "Pioneering in South Brazil" (1878).

in the world, to produce a model of hideous beauty. This success is achieved in their wooden lip-ornament, the crowning glory of the Thlinkeet nation, described by a multitude of eye-witnesses. In all female free-born Thlinkeet children, a slit is made in the under lip, parallel with the mouth, and about half an inch below it. A copper wire, or a piece of shell or wood, is introduced into this, by which the wound is kept open and the aperture extended. By gradually introducing larger objects the required dimensions of the opening are produced. On attaining the age of maturity, a block of wood is inserted, usually oval or elliptical in shape, concave on the sides, and grooved like the wheel of a pulley on the edge in order to keep it in place. The dimensions of the block are from two to six inches in length, from one to four inches in width, and about half an inch thick round the edge, and it is highly polished. Old age has little terror in the eyes of a

* See Bancroft, *op. cit.*, vol. i., for numerous citations from original observers regarding these customs.

Thlinkeet belle; for larger lip-blocks are introduced as years advance, and each enlargement adds to the lady's social status, if not to her facial charms. When the block is withdrawn, the lip drops down upon the chin like a piece of leather, displaying the teeth, and presenting altogether a ghastly spectacle. The privilege of wearing this ornament is not extended to female slaves."

In this method of adornment the native Americans are, however, rivaled, if not eclipsed, by the negroes of the heart of Africa.

"The Bongo women" (says Schweinfurth*) "delight in distinguishing themselves by an adornment which to our notion is nothing less than a hideous mutilation. As soon as a woman is married, the operation commences of extending her lower lip. This, at first only slightly bored, is widened by inserting into the orifice plugs of wood, gradually increasing in size, until at length the entire feature is enlarged to five or six times its original proportions. The plugs are cylindrical in form, not less than an inch thick, and are exactly like the pegs of bone or wood worn by the women of Musgoo. By this means the lower lip is extended horizontally till it projects far beyond the upper, which is also bored and fitted with a copper plate or nail, and now and then by a little ring, and sometimes by a bit of straw, about as thick as a lucifer-match. Nor do they leave the nose intact; similar bits of straw are inserted into the edges of the nostrils, and I have seen as many as three of these on each side. A very favorite ornament for the cartilage between the nostrils is a copper ring, just like those that are placed in the nose of buffaloes and other beasts of burden for the purpose of rendering them more tractable. The greatest coquettes among the ladies wear a clasp, or cramp, at the corners of the mouth, as though they wanted to contract the orifice, and literally to put a curb upon its capabilities. These subsidiary ornaments are not, however, found at all universally among the women, and it is rare to see them all at once upon a single individual; the plug in the lower lip of the married women is alone a *sine quâ non*, serving as it does for an artificial distinction of race."

The slightest fold or projection of the skin furnishes an excuse for boring a hole, and inserting a plug or a ring. There are women in the country whose bodies are pierced in some way or other in little short of a hundred different places, and the men are often not far behind in the profusion with which this kind of adornment is carried out.

"The whole group of the Mittoo exhibits peculiarities by which it may be distinguished from its neighbors. The external adornment of the body, the costume, the ornaments, the mutilations which individuals undergo—in short, the general fashions—have all a distinctive character of their own. The most remarkable is the revolting, because unnatural, manner in which the women pierce and distort their lips; they seem to vie with each other in their mutilations, and their vanity

* "Heart of Africa," vol. i., p. 297.

in this respect, I believe, surpasses anything that may be found throughout Africa. Not satisfied with piercing the lower lip, they drag out the upper lip as well for the sake of symmetry.* . . . Circular plates, nearly as large as a crown-piece, made variously of quartz, of ivory, or of horn, are inserted into the lips that have been stretched by the growth of years, and then often bent in a position that is all but horizontal; and when the women want to drink, they have to elevate the upper lip with their fingers, and to pour the draught into their mouth.

"Similar in shape is the decoration which is worn by the women of Maganya; but, though it is round, it is a ring and not a flat plate; it is called *pelele*, and has no object but to expand the upper lip. Some of the Mittoo women, especially the Loobah, not content with

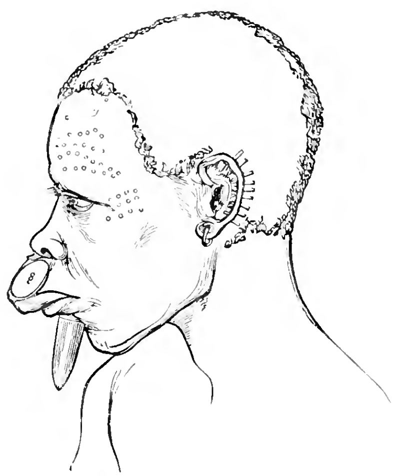


Fig. 4.—Loobah Woman. (From Schweinfurth's "Heart of Africa.")

the circle or the ring, force a cone of polished quartz through the lips as though they had borrowed the idea from the rhinoceros. This fashion of using quartz belemnites of more than two inches long is in some instances adopted by the men."

The traveler who has been the eye-witness of such customs may well add: "Even among these uncultured children of nature, human pride crops up among the fetters of fashion, which, indeed, are fetters in the worst sense of the word; for fashion in the distant wilds of Africa tortures and harasses poor humanity as much as in the great prison of civilization."

It seems, indeed, a strange phenomenon that in such different races, so far removed in locality, customs so singular—to our ideas so revolting and unnatural, and certainly so painful and inconvenient—should

* The mutilation of both lips was also observed by Rohlfs among the women of Kadje, in Segseg, between Lake Tchad and the Benwe.

either have been perpetuated for an enormous lapse of time, if the supposition of a common origin be entertained, or else have developed themselves independently.

These are, however, only extreme or exaggerated cases of the almost universal custom of making a permanent aperture through the lobe of the ear for the purpose of inserting some adventitious object by way of adornment, or even for utility, as in the man of the Island of Mangea, figured in Cook's "Voyages," who carries a large knife through a hole in the lobe of the right ear. Among ourselves, the custom of wearing ear-rings still survives, even in the highest grades of society, although it has been almost entirely abandoned by one half of the community, and in the other the perforation is reduced to the smallest size compatible with the purpose of carrying the ornament suspended from it.

The teeth, although allowed by the greater part of the world to retain their natural beauty and usefulness of form, still offer a field for artificial alterations according to fashion, which has been made use of principally in two distinct regions of the world and by two distinct races. It is, of course, only the front teeth, and mainly the upper incisors, that are available for this purpose. Among various tribes of negroes of Equatorial Africa, different fashions of modifying the natural form of these teeth prevail, specimens of which may be found in any large collection of crania of these people. One of the simplest consists of chipping and filing away a large triangular piece from the lower and inner edge of each of the central incisors, so that a gap is

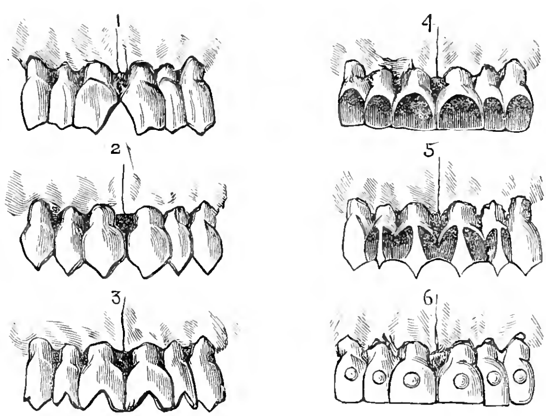


FIG 5.—UPPER FRONT TEETH ALTERED ACCORDING TO FASHION: 1, 2, 3, African; 4, 5, 6, Malay.

produced in the middle of the row in front (Fig. 5, 1). Another fashion is to shape all the incisors into sharp points, by chipping off the corners, giving a very formidable crocodilian appearance to the jaws (2); and another is to file out either a single or a double notch in the cutting edge of each tooth, producing a serrated border to the whole series (3).

The Malays, however, excel the Africans, both in the universality and in the fantastic variety of their supposed improvements upon nature. While the natural whiteness of the surface of these organs is always admired by us, and by most people, the Malays take the greatest pains to stain their teeth black, which they consider greatly adds to their beauty. White teeth are looked upon with perfect disgust by the Dyaks of the neighborhood of Sarawak. In addition to staining the teeth, filing the surface in some way or other is almost always resorted to. The nearly universal custom in Java is to remove the enamel from the front surface of the incisors, and often the canine teeth, hollowing out the surface, sometimes, but not often, so deeply as to penetrate the pulp cavity (4). The cutting edges are also worn down to a level line with pumice-stone. Another, and less common, though more elaborate fashion, is to point the teeth, and file out notches from the anterior surface of each side of the upper part of the crown, so as to leave a lozenge-shaped piece of enamel untouched ; as this receives the black stain less strongly than the parts from which the surface is removed, an ornamental pattern is produced (5). In Borneo a still more elaborate process is adopted : the front surface of each of the teeth is drilled near the center with a small round hole, and into this a plug of brass with a round or star-shaped knob is fixed (6). This is always kept bright and polished by the action of the lip over it, and is supposed to give a highly attractive appearance when the teeth are displayed.

Perhaps the strange custom, so frequently adopted by the natives of Australia, and of many islands of the Pacific, of knocking out one or more of the front teeth, might be mentioned here, but it is usually associated with some other idea than ornament or even mere fashion. In the former case it constitutes part of the rites by which the youth are initiated into manhood, and in the Sandwich Islands it is performed as a propitiatory sacrifice to the spirits of the dead.

The projection forward of the front upper teeth, which we think unbecoming, is admired by some races, and among the negro women of Senegal it is increased by artificial means employed in childhood.*

All these modifications of form of comparatively external and flexible parts are, however, trivial in their effects upon the body to those which I shall speak of next, which induce permanent structural alterations both upon the bony framework and upon the important organs within.

Whatever might be the case with regard to the hair, the ears, the nose, and lips, or even the teeth, it might have been thought that the actual shape of the head, as determined by the solid skull, would not have been considered a subject to be modified according to the fashion

* Hamy, "Revue d'Anthropologie," January, 1879, p. 22.

of the time and place. Such, however, is far from being the case. The custom of artificially changing the form of the head is one of the most ancient and widespread with which we are acquainted. It is far from being confined, as many suppose, to an obscure tribe of Indians on the northwest coast of America, but is found, under various modifications, at widely different parts of the earth's surface, and among people who can have had no intercourse with one another. It appears, in fact, to have originated independently, in many quarters, from some natural impulse common to the human race. When it once became an established custom in any tribe, it was almost inevitable that it should continue, until put an end to by the destruction either of the tribe itself, or of its peculiar institutions, through the intervention of some superior force, for a standard of excellence in form, which could not be changed in those who possessed it, was naturally followed by all who did not wish their children to run the risk of the social degradation which would follow the neglect of such a custom. "Failure properly to mold the cranium of her offspring gives to the Chinook matron the reputation of a lazy and undutiful mother, and subjects the neglected children to the ridicule of their young companions, so despotic is fashion." * It is related in the narrative of Commodore Wilkes's "United States Exploring Expedition," † that "at Niculuita Mr. Drayton obtained the drawing of a child's head, of the Walla Walla tribe (Fig. 6), that had just been released from its bandages, in order to secure its flattened shape. Both the parents showed great delight at the success they had met with in effecting this distortion."

Fig. 6.—Flat-headed Indian Child.

Many of the less severe alterations of the form to which the head is subjected are undesigned, resulting only from the mode in which the child is carried or dressed during infancy. Thus habitually carrying the child on one arm appears to produce an obliquity in the form of the skull which is retained to a greater or less degree all through life. The practice followed by nomadic people of carrying their infants fastened to stiff pillows or boards, commonly causes a flattening of the occiput; and the custom of dressing the child's head with tightly fitting bandages, still common in many parts of the Continent, and even used in England within the memory of many living people, produces an elongated and laterally constricted form.‡ In France this is well known, and so com-

* Bancroft, *op. cit.*, vol. i., p. 238.

† Vol. iv., p. 388.

‡ After the lecture, a gentleman of advanced age showed me a circular depression round the upper part of his head, which he believed had been produced in this manner, as the custom was still prevailing at the time of his birth in the district of Norfolk of which he was a native.

mon is it in the neighborhood of Toulouse, that a special form of head produced in this manner is known as the "*déformation Toulousaine.*"

Of the ancient notices of the custom of purposely altering the form of the head, the most explicit is that of Hippocrates, who in his treatise, "De Aëris, Aquis et Locis," about 400 B. C., says,* speaking of the people near the boundary of Europe and Asia, near the *Palus Mæotis* (Sea of Azov): "I will pass over the smaller differences among the nations, but will now treat of such as are great either from nature or custom; and first, concerning the *Macrocephali.* There is no other race of men which have heads in the least resembling theirs. At first, usage was the principal cause of the length of their head, but now Nature coöperates with usage. They think those the most noble who have the longest heads. It is thus with regard to the usage: immediately after the child is born, and while its head is still tender, they fashion it with their hands, and constrain it to assume a lengthened shape by applying bandages and other suitable contrivances, whereby the spherical form of the head is destroyed, and it is made to increase in length. Thus, at first, usage operated, so that this constitution was the result of force; but in the course of time it was formed naturally, so that usage had nothing to do with it."

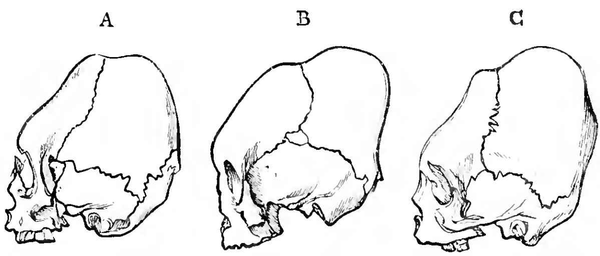


FIG. 7.—SKULLS ARTIFICIALLY DEFORMED ACCORDING TO SIMILAR FASHIONS: A, from an ancient tomb at Tiflis; B, from Titicaca, Peru. (From specimens in the Museum of the Royal College of Surgeons.) C, from the Island of Mallicollo, New Hebrides.

Here Hippocrates appears to have satisfied himself upon a point which is still discussed with great interest, and still not cleared up—the possibility of transmission by inheritance of artificially produced deformity. Some facts seem to show that such an occurrence may take place occasionally, but there is an immense body of evidence against its being habitual.

Herodotus also alludes to the same custom, as do, at later dates, Strabo, Pliny, Pomponius Mela, and others, though assigning different localities to the nations or tribes they refer to, and also indicating variations of form in their peculiar cranial characteristics.

Recent archæological discoveries fully bear out these statements. Heads deformed in various fashions, but chiefly of the constricted,

* Sydenham Society's edition, by Dr. Adam, vol. i., p. 207.

elongated shape, have been found in great numbers in ancient tombs in the very region indicated by Herodotus. They have been found near Tiflis, where as many as one hundred and fifty were discovered at one time, and at other places in the Caucasus, generally in rock-tombs; also in the Crimea, and at different localities along the course of the Danube; in Hungary, Silesia, in the south of Germany, Switzerland, and even in France and Belgium. The people who have left such undoubted evidence of the practice of deforming their heads have been supposed by various authors to have been Avars, Huns, Tartars, or other Mongolian invaders of Europe; but later French authors, who have discussed this subject, are inclined to assign them to an Aryan race, who, under the name of Cimmerians, spread westward over the part of Europe in which their remains are now found, in the seventh or eighth century before our era. As the method of deformation in European specimens is not always identical, it is by no means certain that the custom may not have been in use among more than one nation. Whether the French habit, scarcely yet extinct, of tightly bandaging the heads of infants, is derived from these people, or is of independent origin, it is impossible to say.

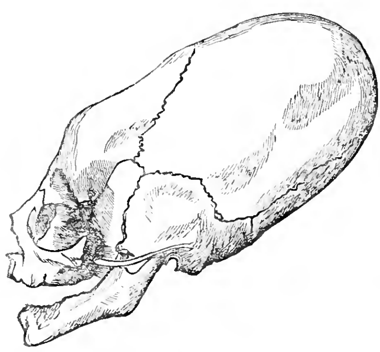


Fig. 8.—Deformed Skull of an Infant, who had died during the process of flattening; from the Columbia River. (Museum of the Royal College of Surgeons.)

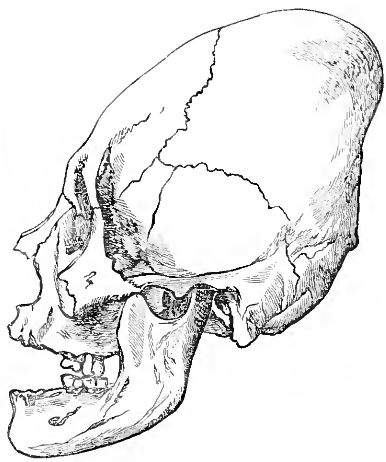


Fig. 9.—Artificially flattened Skull of Ancient Peruvian. (Museum of the Royal College of Surgeons.)

In Africa and Australia no analogous customs have been shown to exist, but in many parts of Asia and Polynesia, deformations, though usually only confined to flattening of the occiput, are common. Though often undesigned, it is done purposely, I am informed by Mr. H. B. Low, by the Dyaks, in the neighborhood of Sarawak. Sometimes, in the islands of the Pacific, the head of the new-born infant is merely pressed by the hands into the desired form, in which case it generally soon recovers that which Nature intended for it. In one island alone, Mallicollo, in the New Hebrides, the practice of permanently depressing the forehead is almost universal, and skulls are even found constricted and elongated exactly after the manner of the Aymaras of ancient Peru.

Though the Chinese usually allow the head to assume its natural form, confining their attentions to the feet, a certain class of mendicant devotees appear to have succeeded to a remarkable extent in getting their skulls elongated into a conical form, if the figure in Picart's "Histoire des Religions," vol. iv., plate 131, is to be trusted.

America is, however, or rather has been, the headquarters of all these fantastic practices, and especially along the western coast, and mainly in two regions, near the mouth of the Columbia River in the north, and in Peru in the south. The practice also existed among the Indians of the southern part of what are now the United States, and among the Caribs of the West India Islands. In ancient Peru, before the time of the Spanish conquest, it was almost universal. In an edict of the ecclesiastical authorities of Lima, issued in 1585, three distinct forms of deformation are mentioned. Notwithstanding the severe penalties imposed by this edict upon parents persisting in the practice, the custom was so difficult to eradicate that another injunction against it was published by the Government as late as 1752.

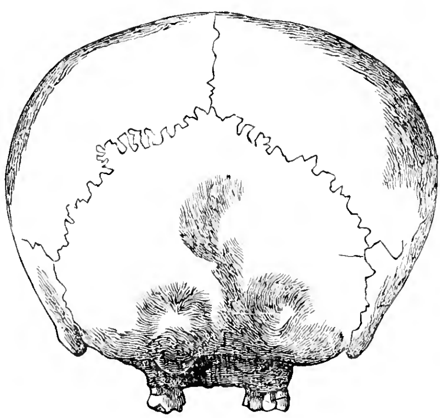


Fig. 10.—Posterior View of Cranium, deformed according to the fashion of flattening, with compensatory lateral widening. (Museum of the Royal College of Surgeons.)

In the West Indies, and the greater part of North America, the custom has become extinct with the people who used it; but the Chinook Indians, of the neighborhood of the Columbia River, and the natives of Vancouver Island, continue it to the present day, and this is the last stronghold of this strange fashion, though under the influence of European example and discouragement it is rapidly dying out. Here the various methods of deforming the head and their effects have been studied and described by numerous travelers. The process commences immediately after the birth of the child, and is continued for a period of from eight to twelve months, by which time the head has permanently assumed the required form, although during subsequent growth it may partly regain its proper shape. "It might be supposed," observes Mr. Kane, who had large opportunities of watching the process, "that the operation would be attended with great suffering, but I never heard the infants crying or moaning, although I have seen their eyes seemingly starting out of the sockets from the great pressure; but, on the contrary, when the thongs were loosened and the pads removed, I have noticed them cry until they were replaced. From the apparent dullness of the children while under the pressure, I should imagine that a state of torpor or insensibility is induced, and that the return to consciousness occasioned by its removal must be naturally followed by a sense of pain."

Nearly, if not all, the different fashions in cranial deformity, observed in various parts of the world, are found associated within a

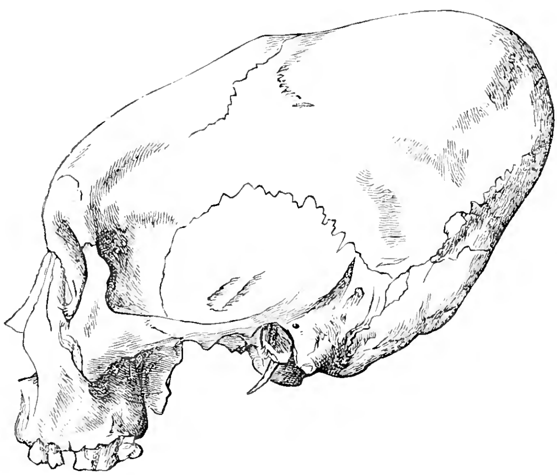


Fig. 11.—Cranium of Koskeemo Indian, Vancouver Island, deformed by circular constriction and elongation. (Museum of the Royal College of Surgeons.)

very small compass in British Columbia and Washington Territory, each small tribe having often a particular method of its own. Many attempts have been made to classify these various deformities, but as they mostly pass insensibly into one another, and vary according as the intention has been carried out with a greater or less degree of perseverance and skill, it is not easy to do so. Besides the simple occipital and the simple frontal compressions, all the others may be grouped into two principal divisions. First (Figs. 8 and 9), that in which the skull is flattened between boards or other compressors, applied to the forehead and back of the head, and as there is no lateral pressure, it bulges out sideways to compensate for the shortening in the opposite direction (Fig. 10). This form is very often unsymmetrical, as the flattening boards, applied to a nearly spherical surface, naturally incline a little to one side or the other ; and when this once commences, unless great care is used, it must increase until the very curious oblique flattening so common in these skulls is produced. This is the ordinary form of deformity among the Chinook Indians of the Columbia River, commonly called "Flat-heads." It is also most frequent among the Quichuas of Peru.

The second form of deformity (Figs. 7, 11, and 12) is produced by constricting bandages of deer's hide, or other similar material, encircling the head behind the ears, usually passing below the occiput behind, and across the forehead, and again across the vertex, behind the coronal suture, producing a circular depression. The result is an elongation of the head, but with no lateral bulging, and with no deviation from bilateral symmetry. This was the form adopted with trifling modifications by the *Macrocephali* of Herodotus, by the Aymara Indians of Peru, and by certain tribes, as the Koskeemos, of Vancouver Island. The "*déformation Toulousaine*" is a modification of the same form.

Fig. 12.—Posterior View of Cranium. deformed according to the fashion of circular constriction and elongation. (Museum of the Royal College of Surgeons.)

The brain, of course, has had to accommodate itself to the altered shape of the osseous case which contained it ; and the question naturally arises, whether the important functions belonging to this organ are in any way impaired or affected by its change of form. All observations upon the living Indians who have been subjected to it, concur in showing that if any modification in mental power is produced, it must be of a very inconsiderable kind, as no marked difference has been detected between them and the neighboring tribes which have not adopted the fashion. Men whose heads have been deformed to an extraordinary extent, as Concomly, a Chinook chief, whose skull is preserved in the museum at Haslar Hospital, have often risen by their own abilities to considerable local eminence, and the fact that the relative social position of the chiefs, in whose families the heads are always deformed, and the slaves on whom it is never permitted, is constantly maintained, proves that the former evince no decided inferiority in intelligence or energy.

Although the American Indians, living a healthy life in their native wilds, and under physical conditions which cause all bodily lesions to occasion far less constitutional or local disturbance than is the case with people living under the artificial conditions and the accummulated predisposition to disease which civilization entails, thus appear to suffer little, if at all, from this unnatural treatment, it seems to be otherwise with the French, on whom its effects have been watched by medical observers more closely than it can have been on the savages in America. "Dr. Foville proves, by positive and numerous facts, that the most constant and the most frequent effects of this deformation, though only carried to a small degree, are headaches, deafnesses, cerebral congestions, meningitis, cerebritis, and epilepsy; that idiocy or madness often terminates this series of evils, and that the asylums for lunatics and imbeciles receive a large number of their inmates from among these unhappy people."* For this cause the French physicians have exerted all their influence, and with great success, to introduce a more rational system in the districts where the practice of compressing the heads of infants prevailed.

I will now pass from the head to the extremities, and shall have little to say about the hands, for the artificial deformities practiced upon those members are confined to chopping off one or more of the fingers, generally of the left hand, and usually not so much in obedience merely to fashion, as part of an initiatory ceremony, or an expiation or oblation to some superior, or to some departed person. Such practices are common among the American Indians, some tribes of Africans, the Australians, and Polynesians, especially those greatest of all slaves of ceremonial, the Feejeeans, where the amputation of fingers is demanded to appease an angry chieftain, or voluntarily performed on the occasion of the death of a relative as a token of affection.

On the other hand, the feet have suffered more, and altogether with more serious results to general health and comfort from simple conformity to pernicious customs, than any other part of the body. But on this subject, instead of relating the unaccountable caprices of the savage, we have to speak only of people who have already advanced to a tolerably high grade of civilization, and to include all those who are at the present time foremost in the ranks of intellectual culture.

The most extreme instance of modification of the size and form of the foot in obedience to fashion, is the well-known case of the Chinese women, not entirely confined to the upper classes, but in some districts pervading all grades of society alike. The deformity is produced by applying tight bandages round the feet of the girls when about five years old. The process is an extremely painful one, and its results are not only an alteration in the relative position of the growing bones and other structures, but an arrest of their development, so that they remain permanently in a stunted or atrophied condition. The alterations of form consist in two distinct processes: 1. Bending the four

* Gosse, "Essai sur les Déformations artificielle du Crane," "Annales d'Hygiène publique," 2 ser., tome iv., p. 8.

outer toes under the sole of the foot, so that the first or great toe alone retains its normal position, and a narrow point is produced in front: 2. Compressing the roots of the toes and the heel downward and toward one another so as greatly to shorten the foot, and produce a deep transverse fold in the middle of the sole (Fig. 14). The whole has now the appearance of the hoof of some animal rather than a human foot, and affords a very inefficient organ of support, as the peculiar tottering gait of those possessing it clearly shows.

But strange as this custom seems to us, it is only a slight step in excess of what the majority of people in Europe subject themselves and their children to. From personal observation of a large number of feet of persons of all ages and of all classes of society in our own country, I do not hesitate to say that there are very few, if any, to be

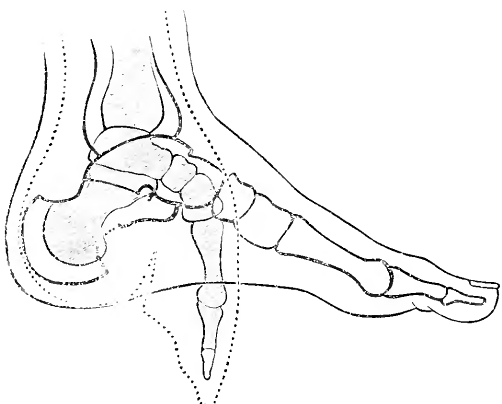


Fig. 13.—Section of Natural Foot with the Bones, and a corresponding Section of a Chinese Deformed Foot. The outline of the latter is dotted, and the bones shaded.

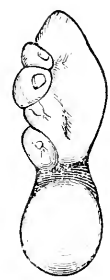


Fig. 14.—Sole of Chinese Woman's Foot.

met with that do not, in some degree, bear evidence of having been subjected to a compressing influence more or less injurious. Let any one take the trouble to inquire into what a foot ought to be. For external form look at any of the antique models—the nude Hercules Farnese or the sandaled Apollo Belvedere; watch the beautiful freedom of motion in the wide-spreading toes of an infant; consider the wonderful mechanical contrivances for combining strength with mobility, firmness with flexibility; the numerous bones, articulations, ligaments; the great toe, with seven special muscles to give it that versatility of motion which was intended that it should possess—and then see what a miserable, stiffened, distorted thing is this same foot, when it has been submitted for a number of years to the "improving" process to which our civilization condemns it: the toes all squeezed and flattened against each other; the great toe no longer in its normal position, but turned outward, pressing so upon the others that one or more of them frequently has to find room for itself either above or under its fellows; the joints all rigid, the muscles atrophied and powerless; the finely formed arch broken down; everything which is beautiful and excellent in the human foot destroyed, to say nothing of the more serious evils which so generally follow—corns, bunions, ingrowing nails, and all their attendant miseries.

Now, the cause of all this will be perfectly obvious to any one who compares the form of the natural foot with the last upon which the shoemaker makes the covering for that foot. This, in the words of

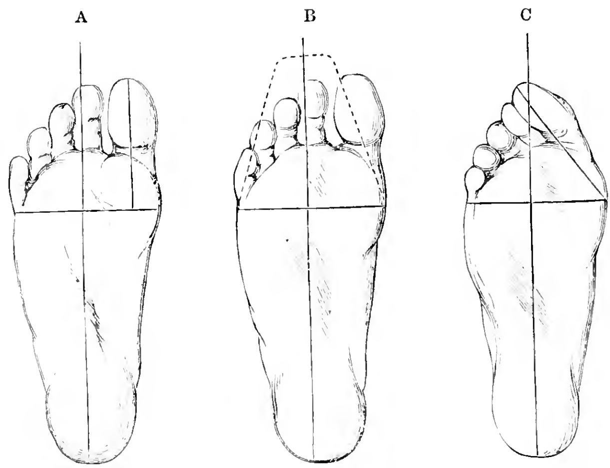


FIG. 15—A, natural form of the sole of the foot, the great toe parallel to the axis of the whole foot; B, the same, with outline of ordinary fashionable boot; C, the necessary modification of the form of the foot consequent upon wearing such a boot.

the late Mr. Dowie, "is shaped in front like a wedge, the thick part or instep rising in a ridge from the center or middle toe, instead of the great toe, as in the foot, slanting off to both sides from the middle, terminating at each side and in front like a wedge; that for the inside or great toe being similar to that for the outside or little toe, as if the human foot had the great toe in the middle and a little toe at each side, like the foot of a goose!" The great error in all boots and shoes made upon the system now in vogue in all parts of the civilized world lies in this method of construction upon a principle of bilateral symmetry. A straight line drawn along the sole from the middle of the toe to the heel will divide a fashionable boot into two equal and similar parts, a small allowance being made at the middle part, or "waist," for the difference between right and left foot. Whether the toe is made broad or narrow, it is always equally inclined at the sides toward the middle line, whereas in the foot there is no such symmetry. The first or inner toe is much larger than either of the others, and its direction perfectly parallel with the long axis of the foot. The second toe may be a little larger than the first, as generally represented in

Grecian art, but it is more frequently shorter; the other rapidly decrease in size (Fig. 15, A). The modification which must have taken place in the form of the foot and direction of the toes before such a boot can be worn with any approach to ease is shown at C. Often it will happen that the deformity has not advanced to so great an extent, but every one who has had the opportunity of examining many feet, especially among the poorer class, must have met with many far worse. The two figured (Fig. 16), one (C) from a laboring workingman, the other (A and B) from a working-woman, both patients at a London

A B C

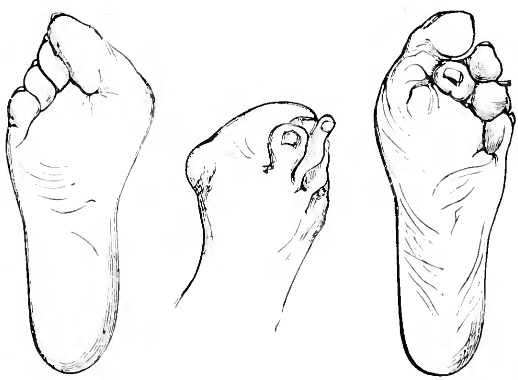


Fig. 16.—English Feet deformed by wearing improperly shaped Shoes. (From Nature.)

hospital, are very ordinary examples of the European artificial deformity of the foot, and afford a good comparison with the Chinese. It not unfrequently happens that the dislocation of the great toe is carried so far that it becomes placed almost at a right angle to the long axis of the foot, lying across the roots of the other toes.

The changes that a foot has to undergo in order to adapt itself to the ordinary shape of a shoe could probably not be effected unless commenced at an early period, when it is young and capable of being gradually molded into the required form. It seems perfectly marvelous that any one who had ever looked at a healthy pair of human feet could have thought of the possibility of wearing a stiff, unyielding shoe of identical form for both right and left, and yet the very trifling difference which is at present allowed is a comparatively modern innovation, and is even now too frequently disregarded, especially where most needed, as in the case of children.

The loss of elasticity and motion in the joints of the foot, as well as the wrong direction acquired by the great toe, are not mere theoretical evils, but are seriously detrimental to free and easy progression, and can only be compensated for in walking by a great expenditure of muscular power in other parts of the body, applied in a disadvantageous manner, and consequently productive of general weariness. The laboring-men of this country, who from their childhood wear heavy, stiff, and badly shaped boots, and in whom, consequently, the play of the ankle, feet, and toes is lost, have generally small and shapeless legs and wasted calves, and walk as if on stilts, with a swinging motion from the hips. Our infantry soldiers also suffer much in the same manner, the regulation boots in use in the service being exceedingly ill adapted for the development of the feet. Much injury to the general health—the necessary consequence of any impediment to freedom of bodily exercise—must also be attributed to this cause. Since some of the leading shoemakers have ventured to deviate a little from the conventional shape, those persons who can afford to be specially fitted are better off as a rule than the majority of poorer people, who, although caring less for appearance, and being more dependent for their livelihood upon the physical welfare of their bodies, are obliged to wear ready-made shoes of the form that an inexorable custom has prescribed.

No sensible person can really suppose that there is anything in itself ugly, or even unsightly, in the form of a perfect human foot; and yet all attempts to construct shoes upon its model are constantly met with the objection that something extremely inelegant must be the result. It will, perhaps, be a form to which the eye is not quite accustomed; but we all know how extremely arbitrary is Fashion in her dealings with our outward appearance, and how anything which has received her sanction is for the time considered elegant and tasteful, while a few years later it may come to be looked upon as positively ridiculous. That our eye would soon get used to admire a different shape may be easily proved by any one who will for a short time wear shoes constructed upon a more correct principle, when the prevailing pointed shoes, suggestive of cramped and atrophied toes, become positively painful to look upon.

Only one thing is needed to aggravate the evil effect of a pointed toe, and that is the absurdly high and narrow heel so often seen now on ladies' boots, which throws the whole foot into an unnatural position in walking, produces diseases well known to all surgeons in large practice, and makes the nearest approach yet effected by any European nation to the Chinese custom which we generally speak of with surprise and reprobation. And yet this fashion appears just now on the increase among people who boast of the highest civilization to which the world has yet attained.

But when, in spite of all the warnings of common sense and experience,* we continue to torture and deform our horses' mouths and necks with tight bearing-reins, as injurious, as useless, and as ugly as any of these customs we practice on ourselves, and all for no better reason, we may well say with Dr. Johnson, "Few enterprises are so hopeless as a contest with fashion."

* See "Bits and Bearing-Reins," by Edward Fordham Flower. Cassell & Co., 1879.

I must speak last upon one of the most remarkable of all the artificial deformities produced by adherence to a conventional standard, and one which comes very near home to many of us.

It is no part of the object of the present discourse to give a medical disquisition upon the evils of tight-lacing, though much might be said of the extraordinary and permanent change of form and relative position produced by it, not only on the bony and cartilaginous framework of the chest, but also in the most important organs of life contained within it, changes far more serious in their effects than those of the Chinook's skull and brain, or the Chinese woman's foot. It is only necessary to compare these two figures (Figs. 17 and 18), one

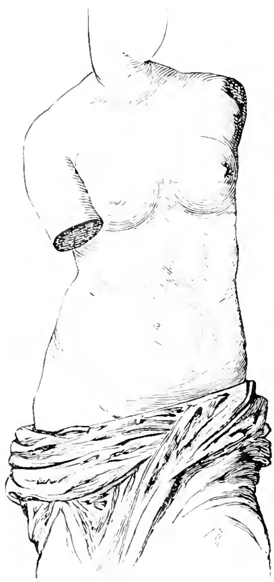


Fig. 17.—Torso of the Statue of Venus of Milo.

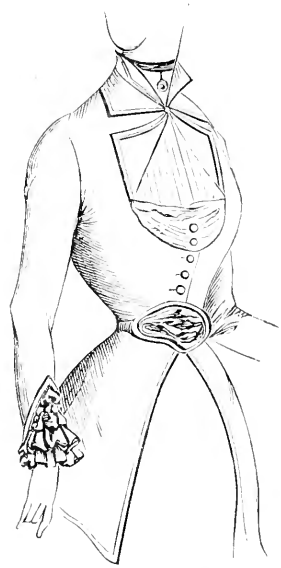


Fig. 18.—Paris Fashion, May, 1880.

acknowledged by all the artistic and anatomical world to be a perfect example of the natural female form, to be convinced of the gravity of the structural changes that must have taken place in such a form, before it could be reduced so far as to occupy the space shown in the second figure, an exact copy of one of the models now held up for imitation in the fashionable world. The wonder is not that people suffer, but that they continue to live, under such conditions.

It is quite possible, or even probable, that some of us may think the latter the more beautiful of the two. If any should do so, let us pause to consider whether we are sure that our judgment is sound on the subject. Let us remember that to the Australian the nose-peg is an admired ornament, that to the Thlinkeet, the Botocudo, and the

Bongo negro, the lip dragged down by the heavy plug and the ears distended by huge disks of wood are things of beauty, that the Malay prefers teeth that are black to those of the most pearly whiteness, that the Western Indian despises the form of a head not flattened down like a pancake, or elongated like a sugar-loaf, and then let us carefully ask ourselves whether we are sure that in leaving nature as a standard of the beautiful, and adopting a purely conventional criterion, we are not falling into an error exactly similar to that of all these people whose tastes we are so ready to condemn.

The fact is that, in admiring such distorted forms as the constricted waist and symmetrically pointed foot, we are simply putting ourselves on a level in point of taste with those Australians, Botocudos, and negroes. We are taking fashion, and nothing better, higher, or truer, for our guide; and, after the various examples brought forward this evening, may I not well ask—

"Seest thou not what a deformed thief this fashion is?"

COÖPERATION IN ENGLAND.

By GEORGE ILES.

AT the Coöperative Congress, held in Newcastle-on-Tyne, last May, some very interesting statistics were presented. The latest report of the Registrar is for 1878, and shows the membership of British coöperative societies to have been 560,703, having transacted during the year business amounting to $102,820,000. In 1861—the first year of the reports published by the Registrar—the membership was 48,184, with a business for that year of $7,360,000. This remarkable growth of coöperation within recent years has brought it from the obscurity of a theory, held by the general public to be either impracticable altogether, or practicable only within special and narrow limits, to the importance of a power which is transforming in appreciable measure the entire retail trade of Great Britain, and which, at the last election, had aroused an antagonism which excluded from Parliament two well-known publicists of high character and ability.

The coöperative movement, as far as it has gone, has been chiefly directed toward so improving the ordinary methods of retail trade as to confer moral benefit and material profit upon the working-classes. The wastes of our present plans of retail distribution are very obvious: our streets swarm with inconsiderable shops, repetitions of one another, and maintained at an enormous aggregate expense. Competition has far exceeded the bounds within which it does good, by spurring industry and inciting emulation; without regard to the strictly limited wants of a community, shopkeepers begin business in cities and towns where overtrading already prevails, and the consequence is loss to the investors and demoralization all round. Excessive competition has led to a system of giving credit, which supports dishonest debtors at industry's cost, and keeps multitudes of book-keepers, collectors, and lawyers employed at the charge of productive labor. Furthermore, under existing methods, the losses to society from adulteration continue and increase from year to year. The delusive appearance of cheapness is often bought at a ruinous price. Owen used to declare that an adulteration of pure long-fiber cotton with but one seventh of coarse short staple lessened the wearing value of the fabric one half, and, in the paint-trade, sulphate of baryta is largely mixed with white-lead, yet the sulphate has no covering power whatever as a pigment, and absorbs much valuable oil. The standard of an article, such as coffee, sugar, or paint, once lowered by fraudulent admixture, can scarcely ever be raised again, as the common run of people are poor judges of what they buy, and hesitate to pay the price of a pure and sound article, instead of the current price for really inferior wares which look as well.

All this struck some needy flannel-weavers of Rochdale nearly forty years ago, and, by weekly subscriptions of twopence each, under the name of the "Equitable Pioneers," they began a small store for the sale of provisions and groceries; they did not attempt, at first, to sell dry goods or other merchandise subject to the caprices of fashion, or the equal caprices of a variety of customers, whose tastes might not be well judged by the managing committee. These Rochdale weavers plainly saw that all that keeps the big shops in a town from completely eating up the petty ones is the uncertain and fluctuating character of their custom; so they agreed among themselves to stick to their store for what it could sell them, which they could safely do, as they managed it honestly and well. Once, too, when their flour-mill went badly for a time, they kept on using the ill-made flour until they had all put right, showing their confidence in ultimate success by cheerfully bearing temporary loss. From twopenny beginnings, the Rochdale store has grown until, at the end of 1878, it numbered 10,187 members, having transacted during the year a business of $1,450,000, with a profit of $257,000, the expenses being reduced by good management to two per cent. Although the "Equitable Pioneers" were by no means the first society formed in England for coöperative distribution, yet, as one of the earliest among existing societies, its pre-eminent success has made it the model for imitation wherever a new society is being established, or it is necessary to rectify the imperfect working of a society already in business. The "History of the Society of Equitable Pioneers to 1857," written by George Jacob Holyoake, attracted so much interest that a second era of their history to 1878 has been given to the world by the same author, who has also written the "History of Coöperation," in two volumes, which all should read who wish to know how the movement arose, who labored for it, and what its ultimate aims are.

The rules of the Rochdale society are accepted by the chief exponents of coöperation as being thoroughly wise and judicious. The society sells its goods at the current rates charged by retail merchants, thus avoiding the direct underselling of shopkeepers, and withholding the profits of their system from non-subscribers. Buyers are given metal tokens, representing the value of the cash they pay in. Quarterly stock is taken, and the rate of profit ascertained; then, after paying subscribers to capital their interest at five per cent. per annum, buyers are paid in cash, or credited in the ledger, as they choose, with the amount of their dividends, computed on the tokens brought in. The majority of buyers have their dividends credited to them, thus virtually establishing a savings-bank account, and affording the society means for the extension of its business. Connected with the store are a corn-mill, a shoe-factory, and a soap-factory.

The capital of the coöperative societies is, as a rule, nominally withdrawable. As large investments are often made in real estate, machinery, and other property not readily salable, the necessity has become evident that the trading capital of a society should consist in transferable shares—like those of a joint-stock company—while the deposit capital can only be withdrawable at call. Thus an element of stability is introduced, which prevents a temporary panic or stress of bad times from winding up a really sound society's business.

The societies are managed by committees usually elected for a year, and annual statements of affairs are required by the Government. To watch over the collective interest of the societies, they appointed in 1870 a Central Coöperative Board, with its office in Manchester: this body has obtained for coöperation all needful legislation, and the removal as far as possible of obstacles to its right action. The exemption of the societies as such from income-tax, the limitation of the liability of members for the debts of a society to the sum unpaid upon the shares standing in their names, and an easy method of bequeathing shares without expense, were assured by the Central Committee to which the Central Board succeeded. The Board since its formation has prepared and published the land, building, and mortgage rules, necessary to be observed by societies; and a series of general business rules well thought out and thoroughly tested by experience, whereby new associations may avoid the weaknesses and errors which have been the causes of coöperative failures in the past. For the further assistance of the societies scattered throughout the country, a general secretary of legal attainments is engaged to give such legal and practical advice as from time to time may be sought. The Central Board has established at Manchester "The Coöperative News," a weekly journal, and in addition it circulates broadcast coöperative tracts and pamphlets.

In 1864 a new and important application of the principle of association was made in Manchester—a wholesale society was founded, to supply some hundred and fifty stores. No more serious difficulty had hitherto been met by small new societies than that of buying well. Often remote from the great centers of production, and purchasing in small quantities through a committee or manager of defective knowledge of qualities and prices, much hard-earned money was wasted. Now, in buying through the Wholesale, a society avails itself of the services of expert buyers, who obtain, through their vast purchases, goods at the lowest current prices. Stores are not obliged, as they used to be, to buy more goods than they immediately require, to reach the minimum prices of the market; hence they can carry on business with less capital than they needed formerly. To detect adulterations and determine the quality of wares offered to it, the Wholesale Society employs an analytical chemist. The business of this vast organization now serves more than five hundred societies; it employs buyers in eleven towns and cities in England, Ireland, France, and America. Its subscribed capital is $686,000; the shares, which are five pounds sterling each, are issued on condition that an affiliated society takes out one for each ten members belonging to it, increasing the number annually as its members increase. One shilling per share must be paid on application, on which five per cent. interest is allowed; the remainder can be paid up at once, or be paid up by accumulation of dividends and interest. The sales of the Wholesale Society for the year ending January 11, 1880, were $13,166,545; yet the managers state that these large figures could have been more than doubled had all the societies in the kingdom been joined to the Wholesale, and had they bought from it all the supplies which, with advantage to themselves, they might have taken. The Wholesale Society transacts a large banking business, and this its best advisers deem should be placed upon a separate footing, with its special board of direction. Glasgow has a counterpart to the great Manchester establishment—the Glasgow Wholesale Society has a connection of one hundred and thirty-seven Scottish societies, and during 1879 did a business of $3,066,500.

As instituted at Rochdale, and in scores of other towns and cities, coöperation has been intended by its leaders not only to save to the working-classes the sums commonly absorbed by the wastes, expenses, and profits of ordinary retail trading; it has been designed to train workmen in thrift, in thoughtfulness for the future, and by the gradual accumulation of capital to enable them either to become self-employing, or to own shares in the manufacturing or mining company which may engage them. Some of the societies have provision for building cottages for members out of the dividends credited to them. At Derby and elsewhere hundreds of homes for workingmen have been bought in this way. Coöperation has diffused much knowledge of business, and interest in it, among classes who used formerly to know and care very little about it. The committee and general meetings are usually well attended, and often give scope and opportunity to ability which might without coöperation have lain dormant. Many useful suggestions in times of difficulty have been made by men and women whose only school has been that of hardship and penury.

Societies which strictly follow the Rochdale type set apart annually a portion of their profits for educational purposes, and as a result free libraries and news-rooms are attached to some of the larger stores; the love of information, however, is sometimes wanting in a society whose constant habit is to declare fat dividends. Such societies have averted from them the upward-looking countenances of true coöperators, who regard the lack of food for the mind as demanding at least the ample relief bestowed upon physical hunger.

The citizens of the great metropolis of England have not been ready learners of the men of Rochdale. In the vast extent of London workmen usually live at a distance from their workshops and factories, and the variety of industries is so great that the combinability of the workmen in a town of moderate size and tolerably uniform manufacturing production finds no parallel in London. Then, too, the varied excitements and amusements of the modern Babylon are held to make its work-people more volatile than their provincial brethren, and therefore less susceptible of becoming united and working together. Whatever may be the causes, the fact remains that coöperation scarcely exists in London among the poor, and is mainly confined to the vast associations of the middle and upper classes. The chief of these conduct the Civil-Service stores, the first of which was founded in 1864 by the Post-Office employees. Since 1864 other departments of the Civil Service have joined their *confrères* of the Post-Office, and the business transacted at their warehouses has become enormous. The principles of the London stores are essentially different from those of the provincial ones. In stores of the Rochdale type, capital as such receives no share in profits, it obtains only its interest at five per cent.; in London, subscribers to the capital stock of the Coöperative Associations need not be buyers at all, yet they share in the profits of the business; the plan being to set prices upon the goods sold as much below those of ordinary retailers as will enable the working expenses to be paid and give a reasonable return to the capital embarked. There is no provision in these associations for the accumulation of the sums saved by buying of them, and the underselling of the shopkeepers is direct, and not indirect, as in the provincial stores, where the current retail prices are charged, and the saving comes in the shape of a dividend every six or twelve months. The shopkeeping interest has been much more resentful of the London stores than of provincial ones. In dispossessing shopkeepers of their business, and subjecting them to hardship by employing the economical methods of coöperation, the factory operatives of Lancashire and Yorkshire had the justification of their pressing needs ; no such justification, however, does the London shopkeeper hold that the people of wealth and title have when they desert his counter for the Civil-Service stores. He regards his profits as inalienable rights, and has at times published plaints on his losses of business in the daily press, at once sordid and silly. The Civil-Service Society has been imitated by several large associations among the army and navy, the clergy and the Nonconformists, who derive many noteworthy advantages from their coöperation. United, and being able to give life and fire insurance companies large lines of business without the usual expense of solicitation, members are enabled to take out policies in companies of standing at a discount. Combination, too, has reduced the charges for legal and medical advice, and whether in making his will, or having a tooth drawn, or having the *accouchement* of his wife performed, the London coöperator is better off than other men.

Although the stores, as the coöperative warehouses are called, transact but a very small fraction of the retail trade of London, they are finding imitators so fast that an entire change in the methods of doing business is being brought about. The old way of selling goods on credit and charging in prices a percentage large enough to cover the loss and expenses entailed by the system can not stand before the economy of buying and selling for cash. Then the vast scale of the business of the stores enables them to buy on the best terms directly from producers and manufacturers, and the charges of rent, taxes, and management, are proportionately much less than in small independent concerns. The percentage of total expense to business transacted is but 5¼ on an average for all the British societies, and is perhaps somewhat less in the London stores. Their business is rendered in a large measure uniform by being maintained by a known circle of customers with wants of a fairly calculable character ; and large sums are saved by premises not being needed on a street of high rents for chance custom's sake ; and the stores do not require to expend, when once established, anything for advertisements or other solicitation. The chief retail streets of London contain frequent announcements of "Coöperative prices," "Discounts for cash," and "Discounts increasing with the extent of a purchase"—all evidencing attempts to employ the economical features of coöperation by firms competing with the stores.

No coöperator, however sanguine, believes that the stores will eventually supersede all retail shops. Taste and skill will always secure independence, and a better reward than falls to the lot of those who supply in an ordinary unexcellent way the general wants of their customers. An artistic cabinet-maker or upholsterer, as well as a really good tailor or shoemaker, will never need to offer discounts to retain business ; but all the many things which one factory can turn out as well as another, or one importer can buy with as much facility as his neighbor, must inevitably be distributed, as the struggle for the means of existence grows sharper, with the greatest economy possible. The pleasures of shopping may lose some of their attraction when the cost of keeping up shops depending upon chance custom becomes understood, and when the managers of stores undergo such evolution as to enable them to display their goods with taste and effect. Some of the great English stores look as if all inducing to purchase by tasteful appeals to the eye were among the things to be left behind.

The stores have drawn attention to a principle which may yet find wide development—the organization of supply and demand, so that the uncertainties and difficulties of modern business may be made less oppressive than they are now felt to be. When a particular retail store has its permanent body of purchasers whose money conducts the concern, stocks of goods can be laid in with little of the doubt and uncertainty which must vex the ordinary shopkeeper and subject him to inevitable loss; the same principle leads to yet further economy when, as at Manchester, a wholesale society supplies a stated and large number of stores for their fairly predictable wants. A steadying of the fluctuations of production would occur were wholesale societies federated to manufacturing and importing societies; the whole series conferring mutual benefits among the members, and depriving the speculator, the corner-maker, and the fraudulent bankrupt of their spoils. Such is the ideal of coöperation, to which at a distance, toilsome indeed, its leaders are endeavoring to come in practice. Could the coöperative principle by the integrity and stability of a people spread throughout its trade, the perplexities and losses of business would be enormously reduced. The area over which a merchant's customers are now scattered usually prevents him from knowing much of their personal characters or circumstances. Competition, with its too cheap credit, has made it rarely possible for a wholesale merchant or manufacturer to ask his customer upon what grounds he should be trusted. The knowledge which in olden times used to be directly sought between man and man is now usually obtained through irresponsible commercial agencies, which, however honestly and ably managed, can not and should not take the place of direct inquiry of a trader seeking credit by the merchant or manufacturer who trusts him. The intermediation, too, of the commercial traveler, who does so much of the business of to-day, weakens the sense of responsibility felt at its height when merchant and customer meet face to face; and the extent of bankruptcy within recent years has undoubtedly been widened by the constant and undue solicitation to buy on the part of these commercial travelers, who are interested more in effecting large sales than in ascertaining the soundness of their customers.

The extension of railroads and other means of travel and transportation, by increasing the mutual invasion by merchants of each other's territory, has had the effect of making constant and expensive solicitation necessary to the maintenance of a "connection." The good will of a business year by year declines in value in the market. In some measure needless competition arises from the improved modern facilities of locomotion by virtue of a curious illusion: merchants and manufacturers seem to think that the mere aggregation of the small districts in which business was done in the past increases the area of the total market, as if taking down fences affected the aggregate acreage of contiguous farms. If the factories and warehouses engaged in the supply of the home market were distributed throughout Great Britain in sections of equal population, their over-supply would be plain.

For all the baffling difficulties which the enlargement of the area of trade has introduced into business, and all the parasitical expenses which have fastened themselves upon it, coöperation offers a remedy—a remedy, however, only to be applied as intelligence and trustworthiness advance. The costly war and waste of isolated competition are signs and tokens that men can not trust each other, and have not mutual forbearance enough to combine for common ends in securing for themselves competence and content.

The leaders of English coöperation, while busily engaged in forwarding their plans of distribution, are constantly striving to apply their principles to the more important field of production. If the identification of the interests of buyer and seller is fraught with advantage, still greater advantage awaits the successful fusion of the interests of capital and labor. Up to the present time, however, the experiments in this direction have not been promising, and the case of production now seems to stand where the case of distribution did forty or fifty years ago. Workmen are not educated up to it yet; neither, it would seem, are the men of capital. The Messrs. Briggs, at their Whitewood collieries, divided for several years a percentage of their profits among their employees, leaving for their own share a sum larger than they believed would have come to them under the usual system of hiring. A plan similar to that of the Messrs. Briggs has been followed by Messrs. Fox, Head & Co., at Middleborough. Another method adopted extensively in Yorkshire and Lancashire is for workmen to invest their savings in shares of joint-stock manufacturing companies. The vast business now conducted by coöperative stores has in some measure opened up a path for coöperative manufacturing, but to an extent very limited in proportion to the business transacted, and in a manner very remote from perfect coöperation. At the Leicester shoe-factory and elsewhere the workmen are hired for wages, just as ordinary capitalists hire, and have no share in profits. The difficulties of managing a store are not few, but they are far less troublesome than conducting production on purely coöperative principles. When every workman in a concern has a voice and vote, in the present state of morals and intelligence, the disputes are interminable as to their respective rates of payment, the proportions of profit which shall be divided between capital, labor, and buyer, and the general policy of the business. Many coöperative workshops have through these disputes failed miserably, and either fallen into individual hands or been converted into joint-stock companies. These failures of coöperative production have done somewhat to allay the bitterness of class-feeling among workmen toward their employers. They find how rare really good business ability is, and how necessary to success it is. They find that it is requisite at times to guard intentions secretly, and to practice a boldness quite impossible when hundreds of interests exist to be consulted, timid about deputing full powers either to managers or committees.

Workmen who have toiled to save a few pounds, and have lost them in a coöperative workshop, have awakened to the fact that the gains of the capitalist are not merely interest on his money, but also payment for the exercise of his judgment, foresight, and executive ability, without which his wealth, however great, would fast melt away in the strifes of business. It is true that coöperation seeks to abolish many of the hazards which make modern business require unusual talent for its management; judgment will be relieved from many questions when credit is curtailed, and consumers are federated to a factory conducted by their own capital and directors; yet in the actual present, while coöperation still remains in its infancy, the existing conditions of competition beset capitalists with difficulties of which only experience has made workmen aware.

MODERN ASPECTS OF THE LIFE-QUESTION.*

By Professor GEORGE F. BARKER.

The number of roots in our equation of life increases the difficulty of solving it, but by no means permits the acceptance of the lazy assumption that it is altogether insoluble or reduces a sagacious guess to the level of the prophecy of a quack.—Haughton.

THE discovery of new truth is the grand object of scientific work. The exultation of feeling which comes from the possession of a fact, which now, for the first time, he makes known to men, must ever be the reward of the scientific worker. As investigators and as students of science we are met here to-day at this our annual session. Each of us during the past year has been endeavoring to push outward further into the unknown, the boundary of present knowledge. When, therefore, we thus meet together, it is fitting that, from time to time, our attention should be called to the progress which has been

* Address of the retiring President of the American Association for the Advancement of Science, delivered at the Boston meeting, August 25, 1880.

made along some one of the various lines of research, and to the milestones which mark the epochs of advance along the way which science has traveled. Moreover, we may profitably sum up at such times the work done in particular directions, and encourage ourselves with prospective and retrospective glances. In these summings up, however, a difficulty arises. The range of modern scientific thought includes an immense area. The field of knowledge is already so vast that, seen from the vertical distance necessary to make a wide survey, that small portion of it which is familiar to any one individual is scarcely visible. In consequence, to use a mechanical figure, the solid contents of a man's acquirements being given, the depth thereof is inversely as the area covered. He, therefore, who undertakes to speak even for one single department of science distributes his stock of knowledge over so broad a surface that in places it must become dangerously thin. It is, therefore, with a very keen sense of the temerity involved in the undertaking that I ask your attention, during the hour allotted me, to some points which appear to me to have been recently gained in the discussion of the question of life.

My friend and predecessor, Professor Marsh, opened his excellent address at Saratoga with the question, "What is Life?" In a somewhat different sense I too ask the same question. But I fear it is only to echo his reply, "The answer is not yet." The result, however, can not long be doubtful. "A thousand earnest seekers after truth seem to be slowly approaching a solution." And, though the *ignis fatuus* of life still dances over the bogs of our misty knowledge, yet its true character can not finally elude our investigation. The progress already made has hemmed it in on every side; and the province within which exclusively vital acts are now performed narrows with each year of scientific research.

What now are we to understand by the word "Life" in this discussion? A noteworthy parallel is disclosed in the progress of human knowledge between the ideas of life and of force. Both conceptions have advanced, though not with equal rapidity, from a stage of complete separability from matter to one of complete inseparability. Life is now universally regarded as a phenomenon of matter, and hence, of course, as having no separate existence. But there still exists a certain vagueness in the meaning of the term "life." Two distinct senses of this word are in use; the one metaphysical, the other physiological. The former, synonymous with mind and soul, at least in the higher animals, has been evolved from human consciousness; the latter has arisen from a more or less careful investigation of the phenomena of living beings. It need scarcely be said that it is in the sense last mentioned that the word "life" is used in science. The conception represents simply the sum of the phenomena exhibited by a living being.

Moreover, the progress which has been made in the solution of the life-question has been gained chiefly by investigation of special functions. But the functions of a vital organism are themselves vital. What, then, is the meaning of "vital" as applied to a function? Fortunately, the answer is not difficult. "Life," says Küss, the distinguished Strasburg physiologist, "is all that can not be explained by chemistry or physics." Guided by such a definition the work of the physiological investigator is simple. He has only to test each separate operation which he finds going on in the organism, and to declare whether it be chemical or physical. If it be either, then, since each function is non-vital, the entire organism must be non-vital also. Hundreds of able investigators, provided with the most effective appliances of research, are now in full cry after the life-principle. Naturally, a vast amount of collateral knowledge is accumulated in the process. The quantitative as well as the qualitative relations of things are fixed and many important facts are collected.

With the object in view thus clearly defined, we are not surprised that great progress has been made. A vital process, like the catalytic ones of the older chemistry, was found by such research to be simply a process which, for want of sufficient investigation, is not yet understood. While therefore, undoubtedly, much work yet remains to be done in the realm still called vital, the prophetic vision is already bright which will witness the last traces of inexplicable phenomena vanish and the words expressing them relegated to the limbo of the obsolete.

As a first result of recent work, the living organism has been brought absolutely within the action of the law of the Conservation of Energy. Whether it be plant or animal, the whole of its energy must come from without itself, being either absorbed directly or stored up in the food. An animal, like a machine, only transforms its energy. Lavoisier's Guinea-pig placed in the calorimeter gave as accurate a heat-return for the energy it had absorbed in its food as any thermic engine would have done. But the parallel goes further. The mechanical work of an engine is measured by the loss of its heat and not of its substance. So the mechanical or intellectual work of a living being is measured by the amount of food rather than the amount of tissue which is burned. The energy evolved daily by the human body would raise it to a height of about six miles.

But, besides heat, work may be the outcome of the organism; and this through the agency of the muscles. Their absolute obedience to mechanical law in their mode of action has been admirably established by Haughton. The work a muscle does, it does in contracting. It is to the mechanism of muscle-contraction that we are indebted for another illustration of our subject.

When work is done by a muscle in contracting, three changes are observed to take place in its tissue: First, there is a loss of its electric tension; second, there is an evolution of heat in it; and, third, carbon dioxide appears there, and its reaction, before neutral, becomes acid.

Matteucci was the first to observe and to call attention to the remarkable similarity, in structure and in the mechanism of operation, between striated muscular fiber and the electric organ of certain fishes. Recently, Marey has repeated and extended his observations. In structure, the electric organ is made up, like the muscle, of columnar masses each separable transversely into vesicular sections. In a torpedo weighing seventy-three pounds, there were 1,182 of these columns, with 150 sections, on an average, in each. In the muscles which bend the forearm, there are 798,000 fibrillæ. As to the mechanism, alike in muscle and in electric organ, an electric current stimulates action on opening and on closing the circuit, but not when it is flowing; the same phenomena take place in both with the direct and with the inverse current; both are reflex; stimulation of the electric nerve produces discharge, as that of the motor nerve causes muscular shock; an entire paralysis follows nerve-section; curare paralyzes both; and tetanus results in both from rapid currents or from strychnine.

Still more striking analogies are furnished by the investigation of the susurrus or muscular sound, first noticed in 1809 by Wollaston. This sound is produced by all muscles when in the state of contraction, the pitch of the note being not far from thirty vibrations per second. It is evidently only the intermittent discharge of the muscular fiber. A single excitation produces a muscular shock. As this production requires from eight to ten hundredths of a second, it is evident that, if another stimulus be applied before the first has disappeared, the two will coalesce; and when twenty per second reach the muscle it becomes permanently contracted or tetanized. By means of a very sensitive myograph, Marey has found that in voluntary contraction the motor nerves are the seats of successive acts, each of which produces an excitation of the muscle. In 1877 Marey examined similarly the discharge of the torpedo, and found a most complete correspondence between it and muscular contraction. Since electric tension disappears from a muscle during contraction, is not the evidence conclusive that muscular contraction, like the discharge of the electric organ of the torpedo, is an electrical phenomenon?

Granting electric discharge to be the cause of muscle-contraction, what is its origin? That it is not carried to the muscle by the nerves follows from the fact that a muscle will still contract when deprived of all its nerve-fibers. It must therefore be generated within the muscle itself. To reach a solution of the problem we must obviously follow the analogies of its production elsewhere.

Perhaps no single question in physics has been more keenly discussed than this one of the origin of electric charge. The memorable conflict between Galvani and Volta, between animal electricity and the electricity of metallic contact, succeeded by the even more triumphant overthrow of the latter and the establishment ultimately by

Faraday of the electro-chemical theory—these are facts fresh in all our memories. The justice of time, however, in this case, if it has been tardy, has been none the less sure. The experiments of Thomson have vindicated Volta and established the contact theory as a *vera causa*. And, more curiously still, it now appears to be proved that both contact and chemical action underlie the production of that very animal electricity so stoutly battled for by Galvani and his associates.

Volta's experiments to prove that a difference of potential is developed by the contact of two heterogeneous metals were not crucial. But Thomson, repeating them with the aid of more delicate apparatus, has shown that, whenever copper and zinc are brought in contact, the copper becomes negative to the zinc. In proof that the chemical action of atmospheric moisture was not the cause of the phenomenon, he showed that, when a drop of water served to connect the copper and the zinc, no charge at all was produced. The fact may therefore be regarded as established, as the result of numerous and varied experiments, that a difference of electrical potential is always developed at the surfaces of contact of heterogeneous media. Not only is this true of solids in contact with solids, but also of solids in contact with liquids, and of liquids in contact with each other. Of course, the production of electricity by contact must result from a loss of energy elsewhere. In the opinion of Cumming, it is the loss of energy which is owing to the unsymmetrical swinging of the molecules on the two sides of the surfaces of contact, which reappears as difference of potential between the solids or as the energy of electrical separation.

But we may carry the sequence yet another step backward. The energy which is thus lost at the surfaces of separation must be heat, and this junction must be cooled thereby. Thus the production of thermo-electricity is seen only to be a special case of a general law, a view to which the well-known Peltier effect gives support. In this phenomenon, when two metals are joined together in the form of a ring and one junction is heated, a current is produced which cools the other junction. From a study of these conditions, Thomson has concluded that the absorption of heat in a thermo-electric circuit varies for different metals with the direction of the current. Thus in iron, the current from hot to cold absorbs heat, while in copper the current which absorbs heat is from cold to hot. In entire accordance with these results are the conclusions recently reached by Hoorweg. Whenever two conductors come into contact, motion of heat results in the development of electricity, the current produced existing at the cost of heat at one part of the point of contact, and evolving heat at the other for a result. Hence all voltaic currents are thermo-currents.

To return to the muscle, it must now be apparent that the electrical charge which appears in its fiber may have its origin in so purely a physical cause as the contact of the heterogeneous substances of which the tissue is built up; the maintenance of this charge being effected by chemical changes going on constantly in the substance of the muscle, by which the carbon dioxide is produced, which is shown to be a measure of the work done.

Conceding, now, that muscular contraction is of the nature of an electric discharge, by what mechanism is the contraction effected? A string of electrified masses, like a muscular fibril, would seem at first to oppose the view now advanced. Such a row of particles would indeed attract each other when electrified and shorten the length of the whole. But the force of contraction would increase as the length diminished; whereas the fact in the case of the muscle is precisely the reverse. Two theories have been advanced to account for the result. The first, proposed by Marey, likens the muscular fiber to a string of india-rubber which, when stretched, contracts upon the application of heat, thus transforming heat directly into work. The other, brought forward and strongly supported by Radcliffe, explains contraction by direct electric charge. Each fiber of the muscle together with its sheath constitutes a veritable condenser, the charge upon the exterior being positive and upon the interior negative. When a charge is communicated to the fiber, lateral compression results from the attraction of the electricities of opposite name, and, since the volume remains constant, elongation is the consequence—precisely as a band of caoutchouc, having strips of tin-foil upon its sides, may be shown to elongate when charged like a condenser. In this view of the matter the normal condition of the muscle is one of charge, of elongation. Contraction results from the simple elasticity of the muscle itself, the function of the nerve being only that of a discharger. Whether this theory represents the actual fact or not, in all its details, it is supported by the existence of *rigor mortis*, by the continued relaxation of muscle during the flow of the current, by the cessation of contraction on the free access of blood, and by many other phenomena otherwise difficult to explain.

From this brief review, does it not seem probable that the phenomenon of muscular contraction may be satisfactorily accounted for without the assumption of "vital irritability," so long invoked? May it not be conceded that the theory that muscular force has a purely physical origin is at least as probable as the vital theory?

Time would fail me to discuss the many other phenomena of the living body which have been found on investigation to be non-vital. Digestion, which Prout said it was impossible to believe was chemical, is now known to take place as well without the body as within it, and to result from non-vital ferments. Absorption is osmotic, and its selective power resides in the structure of the membrane and the diffusibility of the solution. Respiration is a purely chemical function. Oxyhæmoglobin is formed wherever hæmoglobin and oxygen come in contact, and the carbon dioxide of the serum exchanges with the oxygen of the air according to the law of gaseous diffusion. Circulation is the result of muscular effort both in the heart and the capillaries, and the flow which takes place is a simple hydraulic operation. Even coagulation, so tenaciously regarded as a vital process, has been shown to be purely chemical, whether we adopt the hypothesis of Schmidt that it results from the union of two proteids, fibrinogen and fibrino-plastic substance, or the later theory of Hammarsten, that fibrine is produced from fibrinogen by the action of a special ferment.

One function yet remains which can not be altogether omitted from our consideration. This function is that of the nervous system. In structure, this system is well known to us all. In composition, it is made up essentially of a single substance, discovered by Liebreich and called protagon, the specific characters of which have lately been confirmed by Gamgee. In function, the nerve-cell and the nerve-fiber are occupied solely in the reception and the transmission of energy, which is in all probability electrical. There is evidently a close analogy between the nerve and the muscle, the axis cylinder like the fibrilla being composed of cells, and having a positive electric charge upon the exterior surface, which has a tension of one tenth of a volt. Haughton attributes *tinnitus aurium* to the discharge of nerve-cells.

The only objection raised to the electrical character of nerve-energy is based upon its slow propagation. Though thirty years ago Johannes Müller predicted that the velocity of nerve transmission never could be measured, yet Helmholtz accomplished the feat very soon afterward. His results, like those of subsequent experimenters, show that the velocity of propagation of the nervous influence along a nerve, like that of electric transmission, is only about twenty-six to twenty-nine metres in a second. But it should be borne in mind, as Lovering has pointed out, that electricity has no velocity, in any proper sense ; that, since the appearance of an electrical disturbance at the end of a conductor depends upon the production of a charge, the time of this appearance will be a joint function of the electrostatic capacity of the conductor and of its resistance. Since each of these values is directly proportional to length, it follows that the time of transmission will vary as the square of the length of the conductor. While, therefore, in Wheatstone's experiment, he found that electricity required rather more than one millionth of a second to pass through one quarter of a mile of wire, it does not follow that it would traverse 288,000 miles in one second, as he assumed. Indeed, as Lovering has shown, its actual velocity would be only two hundred and sixty-eight miles in an entire second. Hence the marvelous discrepancies which have been observed in the results of experiments made to determine the velocity of electricity on long wires are explained.

In the nerve itself, therefore, the velocity of transmission may be supposed to be the less as its resistance is greater. Now, Weber has shown that animal tissues in general have a conductivity only one fifty-millionth of that of copper. And Radcliffe found that a single inch of the sciatic nerve of a frog measured 40,000 ohms, a resistance eight times that of the entire Atlantic cable. In experimenting to confirm the above law of velocity, Gaugain measured the time of transmission of the electric current through a cotton thread 1·65 metre long, and found it to be eleven seconds. Two similar threads placed consecutively, thus forming a conductor twice as long, required forty-four seconds for the passage of the current, or four times as long. From these data the velocity in the short thread is at the rate of only 0·15 metre in one second; and in the long one only about half this rate, of course. Hence the fact that the energy of nerve moves at the rate of only twenty-eight metres per second is really no proof that it is not electricity.

The higher functions of the nerve-cell, those connected with mental processes, is a field too vast to be entered at this time. The double telegraph line of nerve, motor and sensor in their effect, but, as Vulpian has proved, precisely alike in function, are the avenues of ingress and egress. Every sensory impression is received by the *thalami optici;* every motor stimulus is sent out from the *corpora striata.* In the acts denominated reflex, the action goes from the spinal cord and is automatic and unconscious. Should the impression ascend higher to the sensory ganglia, the action is now conscious, though none the less automatic. Finally, should deliberation be required before acting, the message is sent to the hemispheres by the sensory ganglia, and will operates to produce the act. Based on principles which can be established by investigation, a true psychology is coming into being, developed by Bain, Maudsley, Spencer, and others. A physiological classification of mental operations is being formed which uses the terms of metaphysical psychology, but in a more clearly defined sense. Emotion, in this new science, is the sensibility of the vesicular neurine to ideas—memory, the registration of stimuli by nutrition. Reflection is the reflex action of the cells in their relation to the cerebral ganglia. Attention is the arrest of the transformation of energy for a moment. Ratiocination is the balancing of one energy against another. Will is the reaction of impressions outward. And so on through the list.

Among the physical aspects of the mind-question, the problem of the quantitative changes which take place in the organism is a very curious and interesting one. That the energy of the brain comes from the food will be disputed by no one in these days. Hence, the brain must act like a machine and transform energy. There is, then, a purely physiological representation of mental action, concerned with forces which are known and measurable. The researches of Lombard long ago showed the concomitant heat of mental action. Recent researches are equally interesting, which show that mental operations are not instantaneous, but require a distinct time for their performance. By accurate chronographic measurement, Hirsch has shown that an irritation on the head is answered by a signal with the hand only after one seventh of a second; that a sound on the ear is indicated by the hand in one sixth of a second; and that, when light irritates the eye, one fifth of a second elapses before the hand moves. The mechanism of such a process is the following: Suppose the sound "A" is heard by the ear. After a latent period it is translated to some nerve-cells and hence to the brain. From the brain it goes to other cells, ganglion-cells, and to other nerves, and then to the different muscles of the chest and larynx, and then follows the audible response "A." Now, since this whole process requires only one sixth of a second, the question arises, How much of it is psychical? To answer it, the experiment is repeated, but with this difference, that the particular sound to be used is unknown to the experimenter. Before the sound can be repeated by him, therefore, a distinct act of discrimination is required, and the time taken is longer. Calling the time in the first experiment a, and in the second b, the difference $b—a$ is the time required for two distinct actions; one, that of distinguishing the sound, and the other, that of willing the corresponding movement. If, now, it be agreed that only the sound "A" shall be responded to when called, these may be separated, since, no other sound being responded to, the latter action is eliminated. If the time now required be called c, the difference $c—a$ represents the time required for forming a judgment, and $c—b$ the time required for a volition. In making these measurements, Donders used an instrument devised by him, called a noëmotachograph, and also a modification of it, called a noëmotachometer. By these instruments different points of the body can be irritated, different sounds can be produced, and different colors or letters can be shown, all by the electric spark. By subtracting the simple physiological time from the time given in any experiment, the time necessary for recognition may be obtained. By an addition to the apparatus, a second stimulus may be made to follow the first, either on the same or on a different sense, thus enabling the time necessary for a simple thought to be determined. As a result of his experiments, Donders found that the value $b—a$ in the case of a simple dilemma was seventy-five thousandths of a second, this being the time required for recognition and subsequent volition. In the same way $c—a$ has been shown to be forty thousandths of a second, being the time required for simple recognition; there are left thirty-five thousandths of a second as the time required for volition. Moreover, by independent measurement with the noëmotachometer, exactly the same time, one twenty-fifth of a second, is found necessary to enable a judgment to be formed about the priority of two impulses acting on the same sense. If they act on different senses, more time is necessary. So, also, more time is required to recognize a letter by seeing its form than by hearing its sound. A man of middle age, then, thinking not so very quickly, requires one twenty-fifth of a second for a simple thought.

Another important fact concerning nervous action is that its amount may be measured by the quantity of blood consumed in its performance. Dr. Mosso, of Turin, has devised an apparatus called the plethysmograph—drawings of which were exhibited at the London Apparatus Exhibition of 1876—designed for measuring the volume of an organ. The forearm, for example, being the organ to be experimented on, is placed in a cylinder of water and tightly inclosed. A rubber tube connects the interior of the cylinder with the recording apparatus. With the electric circuit, by which the stimulus was applied to produce contraction, were two keys, one of which was a dummy. It was noticed that, after using the active key several times, producing varying current strengths, the curve sank as before on pressing down the inactive key. Since no real effect was produced, the result was caused solely by the imagination, blood passing from the body to the brain in the act. To test further the effect of mental action, Dr. Pagliani, whose arm was in the apparatus, was requested to multiply 267 by 8, mentally, and to make a sign when he had finished. The recorded curve showed very distinctly how much more blood the brain took to perform the operation. Hence the plethysmograph is capable of measuring the relative amount of mental power required by different persons to work out the same mental problem. Indeed, Mr. Gaskell suggests the use of this instrument in the examination-room, to find out, in addition to the amount of knowledge a man possesses, how much effort it causes him to produce any particular result of brain-work. Dr. Mosso relates that, while the apparatus was set up in his room in Turin, a classical man came in to see him. He looked very contemptuously upon it and asked of what use it could be, saying that it couldn't do anybody any good. Dr. Mosso replied, "Well, now, I can tell you by that whether you can read Greek as easily as you can Latin." As the classicist would not believe it, his own arm was put into the apparatus and he was given a Latin book to read. A very slight sinking of the curve was the result. The Latin book was then taken away and a Greek book was given him. This produced, immediately, a much deeper curve. He had asserted before that it was quite as easy for him to read Greek as Latin, and that there was no difficulty in doing either. Dr. Mosso, however, was able to show him that he was laboring under a delusion. Again, this apparatus is so sensitive as to be useful for ascertaining how much a person is dreaming. When Dr. Pagliani went to sleep in the apparatus, the effect upon the resulting curve was very marked indeed. He said afterward that he had been in a sound sleep, and remembered nothing of what passed in the room—that he had been absolutely unconscious; and yet, every little movement in the room, such as the slamming of a door, the barking of a dog, and even the knocking down of a bit of glass, were all marked on the curves. Sometimes he moved his lips and gave other evidences that he was dreaming; they were all recorded on the curve, the amount of blood required for dreaming diminishing that in the extremities. The emotions, too, left a record. When only a student came into the room, little or no effect appeared in the curve; but, when Professor Ludwig himself came in, the arteries in the arm of the person in the apparatus contracted quite as strongly as upon a very decided electrical stimulation.

In an address of the retiring President of this Association, delivered but a few years ago, I find this sentence: "Thought can not be a physical force, because thought admits of no measure." In the light of the rapid advances lately made in investigating mental action, we see that in two directions at least, in its rate of action and of its relative energy, we may already measure thought, as we measure any other form of energy, by the effects it produces.

Passing now to the consideration of the general question of the transformation of energy which is effected by living beings, attention may be called to one or two points in general physics, as bearing upon its solution. The great law of the dissipation of energy, as modified by Thomson from the statement of Clausius, is thus stated: "The entropy of the universe tends to zero." In other words, the energy of the universe available for transmutation is approaching extinction. This conclusion is based upon the fact that while every form of energy can be completely converted into heat, heat can not be completely converted into other forms of energy, nor these into each other. Hence it arises that energy is being gradually dissipated as heat. Moreover, since transformation can only result when heat passes from a higher to a lower temperature, it follows that, when that perfect equilibrium of temperature is reached toward which events are tending, there can be no other energy than heat, and this absolutely inconvertible, irrecoverable. To apply this law to the present case, the muscle, for example, is a machine for transforming the energy of food into work. Since, consequently, this conversion is not complete, it follows that heat must appear as a necessary result of muscular action. The heat of animal life, consequently, is not heat especially provided; it is simply the heat which inevitably results from an incomplete conversion of energy.

Again, the form of chemical action thus far assumed by physiologists to account for the energy of the living animal has been combustion. But the science of thermo-chemistry, as developed in late years by Berthelot and Thomson, has proved that direct union of chemical substances may not only not evolve heat, but may actually absorb it. It appears, too, that thermal changes accompany all forms of chemical change, those of decomposition and exchange as well as those of synthesis. The animal absorbs highly complex substances as food, capable of innumerable stages of retrogressive metamorphosis before elimination. In each of these stages heat is evolved, being the energy successively stored up by the plant when it repeated these stages in the inverse order.

Another point of interest has reference to the modern views of capillarity. In 1838 J. W. Draper showed that capillarity is an electrical phenomenon. Quite recently, Lippmann has developed and extended this view and fully confirmed it. Whenever the free surface of a liquid, curved by capillary action, is electrified it changes its form; and conversely, when such a surface is made by mechanical means to change its form, an electromotive force is developed. Based upon this principle Lippmann constructed a capillary reversible engine and an extremely sensitive capillary electrometer. The former, when a current of electricity was applied to it, developed mechanical work and ran as a motor. When turned by hand, it became an electromotor. In the animal organism there are it is true but a few free surfaces where this action can take place. But Gore has shown that the same phenomenon appears between two liquids in contact, their boundary being altered in character by electrification. Indeed, when we consider the production of electricity by osmose, and of heat and electricity both by imbibition, both capillary phenomena, the wonder is not that so much energy is evolved by the organism, but that it is so little. If the physical and chemical changes which take place within the body took place without it, there would be an abundant evolution of energy. Can we doubt that these changes are the cause of the energy exhibited by the organism?

Thus far, when we have spoken of a living being, we have had reference to the organism as a whole, and this of a rather complex kind. In this view of the case, however, we find that biological microscopists do not agree with us. "The cell alone," says Küss, "is the essentially vital element." Says Beale: "There is in living matter nothing which can be called a mechanism, nothing in which structure can be discerned. A little transparent, colorless material is the seat of these marvelous powers or properties by which the form, structure, and function of the tissues and organs of all living things are determined." And again, "However much organisms and their tissues in their fully formed state may vary as regards the character, properties, and composition of the formed material, all were first in the condition of clear, transparent, structureless, formless living matter." So Ranvier: "Cellular elements possess all the essential vital properties of the complete organism." And Allman, in his address as President of the British Association last year, is still more explicit. "Every living being," he says, "has protoplasm as the essential matter of every living element of its structure. . . . No one who contemplates this spontaneously moving matter can deny that it is alive. Liquid as it is, it is a living liquid; organless and structureless as it is, it manifests the essential phenomena of life. . . . Coextensive with the whole of organic nature—every vital act being referable to some mode or property of protoplasm—it becomes to the biologist what the ether is to the physicist." From these quotations it would seem that even in the highest animal there is nothing living but protoplasm or germinal matter, "transparent, colorless, and, as far as can be ascertained by examination with the highest powers of the microscope, perfectly structureless. It exhibits these same characters at every period of its existence." Neither the contractile tissue of the muscle, the axis-cylinder of the nerve, nor the secreting cell of the gland, is living, according to Beale. Hence it would be fair to draw the inference that no vital force should be required to explain the phenomena of the non-living matter of the body, such as the contraction of the muscle or the function of the nerve. If this be conceded, it is a great point gained; since the phenomenon of life becomes vastly simplified when we have to account for it only as exhibited in this one single form of living matter, protoplasm. In describing its properties, Allman includes this remarkable mobility, these spontaneous movements, and says: "They result from its proper irritability, its essential constitution as living matter. From the facts there is but one legitimate conclusion, that life is a property of protoplasm." Beale, however, will not allow that life is "a property" of protoplasm. "It can not be a property of matter," he says, "because it is in all respects essentially different in its actions from all acknowledged properties of matter." But the properties of bodies are only the characters by which we differentiate them. Two bodies having the same properties would only be two portions of the same substance. Because life, therefore, is unlike other properties of matter, it by no means follows that it is not a property of matter. No dictum is more absolute in science than the one which predicates properties upon constitution. To say that this property exhibited by protoplasm, marvelous and even unique though it be, is not a natural result of the constitution of the matter itself, but is due to an unknown entity, a *tertium quid*, which inhabits and controls it, is opposed to all scientific analogy and experience. To the statement of the vitalist that there is no evidence that life is a property of matter, we may reply with emphasis that there is not the slightest proof that it is not.

Chemistry tells us that complexity of composition involves complexity of properties. The grand progress which organic chemistry has made in recent times has been owing to the distinct recognition of the influence of structure upon properties. Isomerism is one of its most significant developments. The number of possible isomers increases enormously with the complexity of the molecule. Granted that we now know several of the proteid group of substances: how many thousands may there be yet to know? Bodies of such extreme complexity of constitution may well have an indefinite number of isomers. Not only does Chemistry not say that there can not be such a thing, but she encourages the expectation that there will yet be found the precise proteid of which the changes of protoplasm are properties. The rapid march of recent organic synthesis makes it quite certain that every distinct chemical substance of the living body will ultimately be produced in the laboratory; and this from inorganic materials. Given only the exact constitution of a compound, and its synthesis follows. When, therefore, the chemist shall succeed in producing a mass constitutionally identical with protoplasmic albumen, there is every reason to expect that it will exhibit all the phenomena which characterize its life; and this equally whether protoplasm be a single substance or a mixture of several closely allied substances.

But here a word should be said concerning a remarkable physical condition assumed by matter in organized beings. Graham, in 1862, drew the sharp line which separates colloid from crystalloid matter. "His researches have required," says Maudsley, "a change in our conception of solid matter. Instead of the notion of inert, impenetrable matter, we must substitute the idea of matter which in its colloid state is penetrable, exhibits energy, and is widely susceptible to external agents. This sort of energy is not a result of chemical action, for colloids are singularly inert in all ordinary chemical relations, but is a result of its unknown molecular constitution; and the undoubted existence of colloidal energy in organic substances, which are usually considered inert and called dead, may well warrant the belief of its larger and more essential operation in organic matter in the state of instability of composition in which it is when under the condition of life. Such energy would then suffice to account for the simple uniform movements of the homogeneous substance of which the lowest animal consists, and the absence of any differentiation of structure is a sufficient reason for the absence of any localization of function and of the general uniform reaction to local impressions." Graham himself says: "The colloidal state may be looked upon as the probable primary source of the force appearing in the phenomena of vitality." The colloidal condition is the dynamical state of matter; the crystalloidal the static. The former, which is the rule in the organic kingdom of nature, is the exception in the inorganic. Aluminum and ferric hydrates, silicic acid, and a few other inorganic substances, exist in the colloid condition. From analogy there would seem to be but little doubt that the colloid state of these bodies differs from their crystalloid state merely in the size of the molecule. In other words, opal, which is colloid silica, is a polymer of quartz. If this theory be true, there can be no doubt of the vastly greater complexity of a colloidal proteid molecule than of a crystalloid one. Now, it is a very significant fact, in this connection, that not a single organic colloid has ever been synthesized. Gelatine, which is one of the best examples of a colloid, has a comparatively simple structure. And, although Gibbs showed, many years ago, that gelatine was probably an amido-derivative of the sugar group, yet no inverse process has yet given us this substance. That matter in the crystalloid and the colloid forms may be chemically identical, differing only in the size of its molecule, may be quite possible. But it is also possible that the difference may be a physical one. To produce the colloid state from the crystalloid is by no means beyond the power of science. We qualify our previous statement, then, only so far as to say that when the chemist produces a body in the colloidal form, having the identical constitution of protoplasm, there is every reason to believe that it will have the properties of protoplasm.

The important question now arises whether, since the protoplasm of animals is identical with that of vegetables, and the latter is the food of the former, any protoplasm whatever is vitalized by the animal as such. That this identity exists would seem satisfactorily established. Though the protoplasm of vegetables is inclosed within a cellulose bag, it is only a closely imprisoned rhizopod. In the Nitella, it shows all its characteristic irritability, and from Vaucheria it escapes to exhibit all its amœboid movements. Spores swim about by cilia or flagella, and the cell-division of the one kingdom is the same as that of the other. In plants, however, protoplasm seems to be associated with chlorophyl, whose function was for a long time supposed to be to decompose carbon dioxide under the influence of sunlight. But Draper in 1843 showed that this decomposition took place before the chlorophyl was formed. Recent researches have shown that the function of chlorophyl is wholly protective. The assimilative power of the protoplasm reaches its maximum in the orange and yellow rays. Now, Bert has shown that the absorption band in the chlorophyl spectrum is in the exact position of this maximum. Hence, Gautier believes that this substance acts as a regulator of plant respiration, the greater or less amount of luminous energy thus absorbed and transformed being utilized by the protoplasm and stored up. Growth and cell-division, however, are independent of orange light and hence of chlorophyl. In the higher plants these functions are performed by a separate and deep-lying set of cells. But, in the lower, the same cell discharges both functions, assimilation going on in it during the day, and growth chiefly at night. Sachs had already proved that the maximum growth of plants takes place just before daylight, and the minimum in the afternoon. This retarding action of sunlight upon growth is as curious as it is unexpected. It now appears that in orange light plants assimilate—absorb carbon dioxide and evolve oxygen—but do not grow—are not heliotropic ; while in blue light they are strongly heliotropic, but do not give off oxygen. Chlorophyl, however, is not confined to vegetables ; infusoria, hydras, and certain planarian worms are green from the presence of this substance, and Geddes has shown that such animals placed in the sunlight give off a gas which is more than half oxygen. These cells, moreover, contain starch-granules.

A still more striking evidence of this intimate relationship has been developed by Darwin, in his researches upon insectivorous plants. Not only do these plants possess a mechanism for capturing insects, but they secrete a gastric juice which digests them. Nägeli has shown the presence of pepsin in yeast-cells, and attention has lately been called by Wurtz and others to the juice of the *Carica papaya*, which contains a pepsin-like substance capable of peptonizing fibrine completely. Moreover, there is the closest similarity between diastase and ptyaline ; and the milk of the cow-tree, recently examined by Boussingault and found to resemble cream closely in composition, shows the presence of an emulsifying agent in the vegetable kingdom analogous to pancreatine in the animal.

Another most curious proof of the identity of animal and vegetable protoplasm has been given by Claude Bernard, who has shown that both are alike sensitive to the influence of anæsthetics. A sensitive plant exposed to ether no longer closed its leaflets when touched. Assimilation and growth, as well as germination, are arrested by chloroform. The yeast-plant when etherized no longer decomposes sugar to produce alcohol and carbon dioxide ; while the inversive and non-vital ferment still acts to convert the cane-sugar into glucose ; precisely as under these circumstances the diastasic ferment converts the starch of the seed into sugar. By arresting anæsthetically the process by which carbon dioxide is absorbed and oxygen evolved, the true respiratory process, being less affected, now appears ; and Schützenberger has proved that the fresh cells of the yeast-plant breathe like an aquatic animal.

It would seem, then, that the protoplasmic life of animals is identical with that of plants ; a certain measure of destructive metamorphosis taking place in each, evolving energy and producing carbon dioxide and water. When, however, this function is examined quantitatively, its maximum is seen to be reached in the animal. While the assimilative function characterizes the plant, the destructive function distinguishes the animal. Hence it is the function of the plant to store up energy to produce the highly complex protoplasm. This, consumed by the animal as his food, continues his existence as a living being, the energy gradually set free by its successive steps of retrogressive metamorphosis appearing as the work which he performs. If this view be correct, it would follow that every individual substance found in the animal—save only those which result from degradation—must be found in the plant upon which it feeds, and this is the fact. The myosine which Kühne has shown to be the distinctive proteid of muscle, Vines has found in the aleuron-grains of the lupine and the castor-oil plant, along with vitelline, the special proteid of the vitellus. The researches of Weyl and Bischoff have proved that gluten is formed in the dough of wheat-flour by the action of a ferment upon the globuline-substance or plant-myosine which it contains, precisely as Hammarsten has shown fibrine is produced in the action of a similar ferment upon fibrinogen. Not only this ; Hoppe-Seyler has extracted from maize the identical substance which has been shown by Liebreich to be the essential chemical constituent of nerve-tissue, protagon.

The evidence, then, would seem conclusive that, since the protoplasm of the animal and the vegetable kingdoms is identical, the former in all cases being derived from the latter, the animal as such neither produces nor vitalizes any protoplasm. Two inferences seem naturally to follow from this conclusion: 1. That all the properties of animal protoplasm, and of the animal organism of which it constitutes the essential part, must have a previous existence in the plant; 2. That hence the solution of the life-question in the Myxomycetes will solve the life-problem for the highest vertebrate.

Another consideration which must not be left out of the account in any discussion of the life-question is the potent influence of environment. Ordinary examples of this influence pass before our eyes every day. Heat necessitates the germination of the seed, and light causes the plant to grow. Gravity obliges its root to grow downward and its stem to ascend. Certain sensations from without excite inevitably muscular contraction; and a ludicrous idea may provoke laughter in defiance of the will. Epidemic and epizoötic diseases show the dependence of function upon external conditions, and the germ theory demonstrates the utter disproportionality of the cause to the effect. The remarkable similarity in the periodicity observed between sun-spots and the weather has been extended to include the appearance of locusts and the advent of the plague. Even the body politic feels its influence, Jevons having established a coincident periodicity for commercial crises.

The modern theory of energy, however, puts this influence in a still stronger light. As defined hitherto, energy is either motion or position; is kinetic or potential. Energy of position derives its value obviously from the fact that in virtue of attraction it may become energy of motion. But attraction implies action at a distance; and action at a distance implies that matter may act where it is not. This of course is impossible; and hence action at a distance, and with it attraction and potential energy, are disappearing from the language of science. But what conception is it which is taking its place? By what action does the sun hold our earth in its orbit? The answer is to be found in the properties of the ether which fills all space. The existence of this ether, the phenomena of light and electricity abundantly prove. While so tenuous that astronomy has been taxed to prove that it exerts an appreciable resistance upon the least of the celestial bodies, its elasticity is such that it transmits a compression with a wellnigh infinite velocity. On the one hand, Thomson has determined its inferior limit, and finds that a cubic mile of it would weigh only one thousand millionth of a pound; on the other, Herschel has calculated that, if an amount of it equal in weight to a cubic inch of air be inclosed in a cubic inch of space, its reaction outward would be upward of seventeen billions of pounds. Instead of being represented, as is our air, by the pressure of an homogeneous atmosphere five miles in height, such a pressure would represent just such an homogeneous atmosphere five and a half billions of miles high, or about one third the distance to the nearest fixed star! In Herschel's own words, "Do what we will, adopt what hypothesis we please, there is no escape, in dealing with the phenomena of light, from these gigantic numbers, or from the conception of enormous physical force in perpetual exertion at every point throughout all the immensity of space."

Now, as Preston has suggested, if we regard this ether as a gas, defined by the kinetic theory that its molecules move in straight lines, but with an enormous length of free path, it is obvious that this ether may be clearly conceived of as the source of all the motions of ordinary matter. It is an enormous storehouse of energy, which is continually passing to and from ordinary matter, precisely as we know it to do in the case of radiant transmission. Before so simple a conception as this, both potential energy and action at a distance are easily given up. All energy is kinetic energy, the energy of motion. In a narrower sense, the energy of matter-motion is ordinary kinetic energy; the energy of ether-motion, which may become matter-motion, fills the conception of the older potential energy. Giving now to the ether its storehouse of tremendous power, and giving to it the ability to transfer this power to ordinary matter upon opportunity, and we have an environment compared with which the strongest steel is but the breath of the summer air. In presence of such an energy it is that we live and move; in the midst of such tremendous power do we act. Is it a wonder that out of such a reservoir the power by which we live should irresistibly rush into the organism and appear as the transmuted energy which we recognize in the phenomena of life? Truly, as Spinoza has put it, "Man thinks himself most free when he is most a slave."

Such, now, are some of the facts and fancies to be found in the science of to-day concerning the phenomena of life. Physiologically considered, life has no mysterious passages, no sacred precincts into which the unhallowed foot of Science may not enter. Research has steadily diminished day by day the phenomena supposed vital. Physiology is daily assuming more and more the character of an applied science. Every action performed by the living body is sooner or later to be pronounced chemical or physical. And when the last vestige of the vital principle shall disappear, the word "Life," if it remain at all, will remain to us only to signify, as a collective term, the sum of the phenomena exhibited by an active organized or organic being.

I can not close without speaking a single word in favor of a vigorous development in this country of physiological research. What has already been done among us has been well done. I have said with diffidence what I have said in this address, because I see around me those who have made these subjects the study of their lives, and who are far more competent to discuss them than I am. But the laborers in the field are all too few, and the reasons therefor are not far to seek. One of these undoubtedly is the high scientific attainment necessary to a successful prosecution of this kind of investigation. The physiological student must be a physicist, a chemist, an anatomist, and a physiologist, all at once. Again, the course of instruction of those who might fairly be expected to enter upon this work, the medical students of the country, is directed toward making them practitioners rather than investigators. In the third place, the importance of physiological studies in connection with zoölogical research is only beginning in this country to receive the share of attention it deserves. I well remember the gratification I experienced in 1873 upon receiving a letter from Professor Louis Agassiz, asking me to give some lectures at Penikese upon physiological chemistry—a new departure for those times. In this view of the case it seems very appropriate that a new subsection of this Association should be just now in process of formation. We welcome warmly the body of men who form it, and we predict that from the new subsection of Anatomy and Physiology most valuable contributions will be received for our proceedings.

It is a beautiful conception of science which regards the energy which is manifested on the earth as having its origin in the sun. Pulsating awhile in the ether-molecules which fill the intervening space, this motion reaches our earth and communicates its tremor to the molecules of its matter. Instantly all starts into life. The winds move, the waters rise and fall, the lightnings flash, and the thunders roll, all as subdivisions of this received power. The muscle of the fleeing animal transforms it in escaping from the hunter who seeks to use it for the purpose of his destruction. The wave that runs along that tiny nerve-thread to apprise us of danger transmutes it, and the return pulse that removes us from its presence is a portion of it. The groan of the weary, the shriek of the tortured, the voiced agony of the babeless mother, all borrow their significance from the same source. The magnificence of the work of a Leonardo da Vinci or a Michael Angelo; the divine creations of a Beethoven or of a Mozart; the immortal "Principia" of a Newton, and the "Mécanique Céleste" of a Laplace—all had their existence at some point of time in oscillations of ether in the intersolar space. But all this energy is only a transitory possession. As the sunlight gilds the mountain-top and then glances off again into space, so this energy touches upon and beautifies our earth and then speeds on its way. What other worlds it reaches and vivifies we may never know. Beyond the veil of the seen, Science may not penetrate. But Religion, more hopeful, seeks there for the new heavens and the new earth, wherein shall be solved the problems of a higher life.

THE AUSTRALIAN ORNITHORHYNCHUS.

LIKE most other animals of Australia and the neighboring islands, the ornithorhynchus presents some strange peculiarities of structure and habit. Its body is flat, about eighteen inches long, its head and mouth are very much like those of the duck, and it has a short, broad, flat tail like that of a beaver. When young, the animal is

FIG. 1.—ORNITHORHYNCHUS PARADOXUS.

naked; the bill is short, and furnished with soft, fleshy borders, which enable the little ones to lay hold of the part on the body of the mother which affords the milk, but which is not pointed out by any teat. The tongue is large, and is likewise adapted to sucking. In the grown

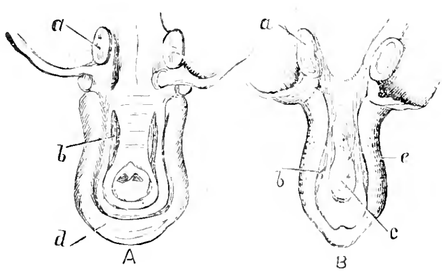


FIG. 2.—Jaws of the Ornithorhynchus Paradoxus. A, upper jaw; B, lower jaw; *a*, back tooth; *b*, flat front tooth; *c*, tongue; *d*, projecting skin; *e*, cross-grooves in the projecting skin.

animal the mouth is broadest in front, where it is rounded off; it is hard, and furnished with a porous skin which projects on both sides and runs around the front. Where this skin touches the forehead it forms a broad fold which falls over the brow, and furnishes an excellent protection for the eyes when the animal is digging in the banks of the streams. The nostrils are close to the end of the upper jaw. In the lower jaw, or rather in the lower part of the mouth, are a number of elevations and depressions which run from the interior of the mouth outward through the protecting skin, and serve, like similar features in the duck, to let the water run out of the mouth when the animal is eating in the thin mud. Within the mouth is a pouch in the cheek, which is used as a place for preserving food. Four horny teeth are set in each jaw, of which the front ones are long and narrow, the others oval and hollow-crowned. The eyes are small and brown, set close down by the bill, and look upward. The ear is entirely hidden under the skin, yet the animal hears very well. The fore feet have five long toes, much alike, with thick, rounded claws ; the toes are connected by a skin which extends over the claws when the animal is swimming, but is drawn back when it is digging. The skin of the hind foot reaches only to the base of the claws. The males when grown have also a movable, sharp spur on the hind foot. The milk-glands are in the lower part of the body, but are not marked by any teats ; the glands swell out on sucking, and the projection thus formed is seized by the broad, soft mouth of the young. It was formerly thought that the ornithorhynchus laid eggs ; but it is now known that it brings its young alive into the world from a double uterus through the so-called urogenital canal. The animal chooses its abode in quiet places on rivers and ponds, where the large-leaved water-plants afford it sure concealment, and the steep, muddy banks allow it to dig deep holes, often fifty feet in length. It is extremely shy, cautious, and alert, and generally swims around under the water, only raising its head for breath, but seldom high enough to be shot at. The young, born about the beginning of December, are put by the mother in a nest which she has prepared at the end of the burrow, and has lined with dry grass. They may be caught by digging them out. They do very well in an aquarium, and make comical, playful pets. The grown animals sleep through most of the day rolled up into a ball, but are lively at night. When free, they

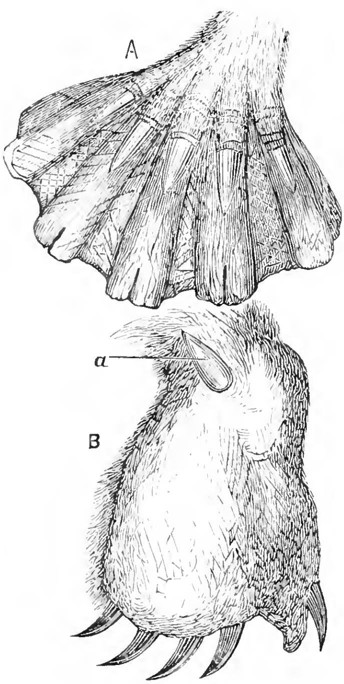


Fig. 3.—A, fore foot of the Ornithorhynchus; B, hind foot ; *a*, spur.

root for worms in the mud, or catch insects and small animals. They have a peculiar, fishy smell, and are eaten by the natives; but this is no sign that they are good, for the natives have no taste. They belong to the lowest group of the mammalia, the *Monotremata*, which includes the two genera *Ornithorhynchus* and *Echidna*; both these genera exhibit an arrangement of the breast- and shoulder-bones which is in a certain degree similar to that of the lizard and the extinct ichthyosaurus. In all the higher mammalia, the humerus is attached to the shoulder in a hollow of the scapula or shoulder-blade; in the ornithorhynchus, the hollow in which the ball of the humerus rests contains a bone connected with the shoulder-blade called the coracoid bone. The breast-bone in the mammalia consists of a broad

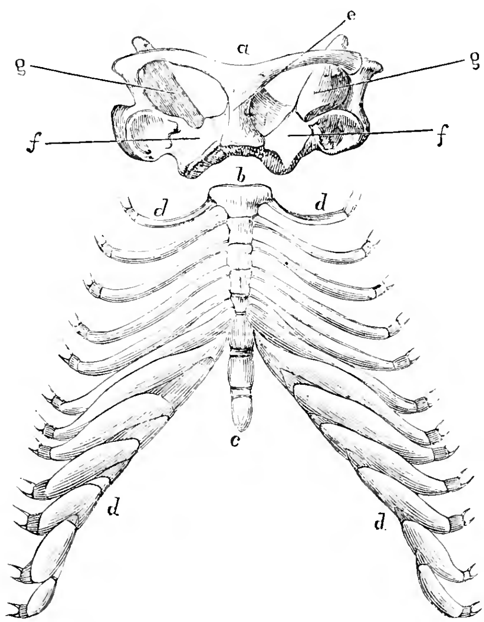


Fig. 4.—The shoulder- and breast-bones and ribs of the Echidna. *a*, T-shaped intermediate bone; *b*, manubrium; *c*, the sword-shaped end of the breast-bone; *d*, cartilaginous ribs; *e*, key-bone; *f*, the coracoid; *g*, the epicoracoid bone.

bone placed in front in quadrupeds, above the others in man, called the manubrium, and several smaller bones, which reach down to the belly, and have ribs on both sides; while in the other mammalia the manubrium is in contact with the neck-bone, in the ornithorhynchus the two coracoid bones are in contact with the manubrium. Some other bones are found on the breast and neck which are wanting in the other mammalia: first, a T-shaped bone which joins the breast-bone from below, and the cross of which bears at each end a neck-bone that reaches to the shoulder-blade; also, on each side in front of the coracoid bone, a so-called epicoracoid bone reaching to the neck. Some of these bones are found occasionally in birds, reptiles, and amphibia. We meet a few other marks of the reptiles in the ornithorhynchus: for example, some ribs are partly or wholly separated from the spine; the hollow called the acetabulum, in which the thigh-bone is attached to the pelvis, is not perfect; the ear is formed very simply, the auditory canal not being wound spirally, and the outer ear being wanting.

THE MYSTERIOUS SOUNDS OF NATURE.

By ROBERT SPRINGER.

THE author of an essay on "The Empire of Tones," which was published at Brunswick a few years ago, wrote: "The globe is played upon around its whole circuit by the billows of the mighty ocean; it is encompassed by the strata of the atmosphere ever moving in sound-waves; and is swept from pole to pole by a flood of the most diversified tones which have their origin in nature. Over the eternal snow-peaks of the mountains, where all life has long since been made stark by the cold, howl icy storms like the voice of a gigantic organ. In the deep bosom of the earth the miner hears the murmur of the subterranean waters, the whistling of the jets of escaping gases, and the monotonous trickling of the gathered dampness. The human race has heard the voices of creation for thousands of years, from its childhood; but how incompetent has science been till now to explain the origin and meaning of these innumerable sounds!" A notice of some of the most remarkable of the sounds which are produced by the acoustic forces of nature will be of interest.

It should be borne in mind that waves of sound produced by a single impulse have the property of putting other waves in motion, so as to prolong the effect and produce a tone from the combination of the wave-movements. From this we may understand how resonances may be caused and harmonies may be heard in nature, the real origin of which may not be perceived by the common observer, or even by the learned investigator. Of such are the mysterious noises heard in the woods of Ceylon, on the banks of the Orinoco, and on the peninsula of Sinai. The rustle of the woods, the roll of the thunder, the crash of the storm, the murmur of the waterfall—all those sounds of the earth and the air of which the poets are so fond, and in which the ancients recognized the prophetic voices of the gods—sober science seeks to trace back to the same law whose operation is perceived when the bullet whizzes through the air, when the wind whistles through the crack of the door or window, when the burning wood snaps in the fireplace, when the stove-door crackles in cooling, when the teakettle sings that the water is boiling. Most of these sounds, which are produced by quickly succeeding impulses, approach in some degree to being musical tones. Water, in particular, has the property of giving forth sounds of this character, which vary in quality from the dull moaning of the waves to the charming warble of the gurgling brook and the pattering of the cascade. The great drops of the shower produce their melodies also, which in the cave of Staffa make a genuine water-music.

Among the natural sounds of obscure origin with which mythology and science have been occupied are the rustlings and so-called voices which seem to come from the air, sometimes from the bosom of the earth, and which have been remarked upon in all ages. Autenrieth refers them to the same class as the noises like thunder or the firing of cannon, which the hearers often fail to trace to an apparent cause. Sometimes they seem like the trampling of horses, or the roll of drums, or the clangor of trumpets; at other times, like human voices. In the last case, the sounds are those which are common to all men, and may be interpreted by each hearer as in his own language. To the Romans they spoke Latin, to the Greeks Greek, to the Scotch Highlanders Gaelic. History has notices of these sounds; the Bible descriptions attribute to them a religious significance. They are referred to when it is related that Samuel heard the voice of Jehovah three times in the temple; when Habakkuk, pronouncing the curse on Babylon, spoke of the stones crying out in the walls; when the glad voices of the mountains and waves are mentioned in the Psalms; in the account in John of the voice that cried out from heaven when Jesus went into Jerusalem, and the people wondered whether it was thunder or an angel; in the story of the conversion of St. Paul; and in the account of the pouring out of the Holy Spirit on the day of Pentecost. The profane history of antiquity also tells of voices from above, and ascribes to them a supernatural significance and an influence over the hearts of men. Instances in point are the sounds of battle, and the clash of arms, and the neighing of horses, heard by night, according to Pausanias, on the field of Marathon; the address of the god Pan to the Athenian ambassadors to Sparta, told of by Herodotus; and the voices heard by both armies after the battle of the Romans with the sons of Tarquin. The Germans have myths of the din made by the war-god and his marching hosts, of the wild huntsmen, of strange cries and of the barking of dogs heard in the air; and the French have stories not unlike them.

Accounts have been given in more recent times of air-noises of another kind, or "devil's music," which have been heard in the East, in Europe, and in America, and of which discussions may be found in the acoustic letters of Richard Pohl and in the "Musical Conversations-Lexicon" of Gathy. The devil's voice in Ceylon is heard in clear nights on the hills and among the valleys in different places, passing quickly from one spot to another, sometimes resembling the barking of a dog, sometimes a mournful human voice, and has been described by several travelers, English, Dutch, and German. Autenrieth, Richard Pohl, Schubert, and others have endeavored to trace it to natural causes, but Schleiden gives up a satisfactory explanation of it. Persian traditions tell of a similar phenomenon, the cry of the Gule which is heard in the mountain-region of that country, together with the noises of the ringing of metals, the sound of drums, and the trampling of horses. The traveler Marco Polo, in the thirteenth century, told of noises of weapons and horsemen, the voices of men and musical harmonies which were heard frequently in the desert of Lob; and his contemporary, the monk Rubriquis, described the regions north of the Altai Mountains as the scene of similar manifestations. The devil's voice in Ceylon has been ascribed to the effects of excessive heat; these sounds of the more northern regions are possibly due to the dryness of the climate. The region of Mount Sinai is rich in curious harmonious sounds.

Unaccounted-for sounds have been accompanied in some of the hotter parts of Africa by a light, which may indicate an electrical origin; this has been noticed by several observers on a mountain near Cape Town. A manifestation, which may be called a sound mirage, was described in the "Magasin Pittoresque" in 1852 by an English writer, who related that while traveling in the desert at a time when the atmosphere was clear, and the heat glowing, and everything was quiet, he heard for about ten minutes a joyous sound like the ringing of church-bells. He suggested that the organs of hearing might have been set in vibration through the extreme dryness of the air. (Kinglake, in "Eöthen," relates a similar incident, if this is not the same.) The missionary Cabruta heard on the Orinoco a sound like the reverberations of cannon coming alternately from opposite directions, to which no one could assign an origin; and Humboldt says that the Indians of the same regions tell of the sound of the holy trumpets blown by the Great Spirit.

Similar phenomena have been noticed at different places in Europe, and people remote from each other have alike referred them to a supernatural origin. Among them were the sounds in the air heard by a priest at Aufacq, near Beauvais, of which an account is given in a manuscript of the last century, and the noise of the Arlecan which was heard in a churchyard near Arles. The Slavic peoples on the Adriatic and the Scandinavians of the North are equally inclined to believe in such manifestations and to notice them. The mirage of the *Fata Morgana* is sometimes accompanied with a sound like thunder. The Scottish Highlanders hear a mournful sound in the clefts of the rocks which they ascribe to an evil spirit. Arndt tells of soft tones and cries emanating from the mountains of the Orkney and Shetland Islands. Distinct cracking sounds are heard on the Adriatic Sea.

Echoes are frequently mentioned that repeat the sound six or seven times. Such an echo is said by Pliny to have been at a portico in Olympia; another echo, described by Gassendi, near the grave of Metella, repeated a verse of the "Æneid" eight times. Addison heard in Italy a pistol-shot echoed fifteen times. An echo in the county of Argyll repeats the sound eight times after equal pauses, but with diminishing force. These phenomena are favored by the neighborhood of rocks, caves, and bodies of water. Pierre de Castellane, a French officer who served in Algiers, relates that he heard an echo repeated a thousand times on the mountain-road to Bel-Abbes; it seemed to pass from one mountain to another, and to resound from side to side. Admiral Wrangell, in his work on Siberia, tells of an echo at Teheki, near Kirensk, on the Lena, where a pistol-shot is repeated more than a hundred times among the high rocks, and seems like a volley of musketry, but of the force of a cannon-shot.

Partly of the nature of the echo are the peculiar tones which are produced by the wind or the sea in rocky places. The learned Jesuit Kircher describes several such phenomena as sounding like the twanging of the harp, like an organ, or like bells. They have been noticed in Tartary, in Sweden, on the banks of the Guatemala Lake, and at a waterfall in the province of Kiang-si, China. Pausanias speaks of the tuneful waves of the Ægean Sea; Professor Bruder has perceived the chord of the third of C sharp in them. The experiments of the brothers Heim have made it probable that the resonant property resides in some quality of the waters; and Oersted has discussed the subject of the "Harmony of Waterfalls" in his work on the "Spirit of Nature."

The agency of echoes is also observed in the music of grottoes. A fearful sound has been said to be emitted from the grotto of Smaland near Wibourg, in Finland, as if a living animal were imprisoned there. Similar sounds are attributed to grottoes in Switzerland and the island of Hispaniola. A cave near Barable in Hungary gives out a noise like that of a pistol-shot. Harmonious, soothing tones prevail in other caves, as in Fingal's Cave, Staffa, where the falling water-drops, the breezes, and the rolling waves striking upon the basaltic columns, combine to make it a real cave of melodies. The accord of tones in this cave is no doubt attributable in a great degree to the symmetry of its shape, and the regularity of the form and arrangement of the basaltic columns. Other musical sounds proceed from the bosom of a rock called the Piedra de Carichana Vieja, on the banks of the Orinoco; they begin at sunrise, and are attributed to the action of changes of temperature. The musical sounds which are heard on the heights between Mount Sinai and the Gulf of Suez, the bell-tones of the Djebal Nakus rock in the Red Sea, and the noises like thunder in the region of Sinai which are mentioned by Burckhardt, are caused by the rolling of the sands among the rocks.

The sonorous property of rocks is also manifested in the phonoliths or ringing stones, of which several remarkable ones are known. The embassy of the East India Company to China found a rock near the city of Taucham, which gave out a noise like the sound of a trumpet whenever it was rubbed with the finger. Such stones are not uncommon in the department of the Loire, in France; and the basin of a fountain in the court of the Institute of France, in Paris, was observed by Elwart to give the chord of F sharp when struck by the hand.

Plants also afford their peculiar sounds and music. Of this nature were the oracular voices of the oaks at Dordona, a rustling of the trees around the temple of Zeus, which, with the accompanying murmur of the sacred fountain, was held to be prophetic. The rustling of the trees was regarded by the Scandinavians and the Celts as a language of nature, full of significance, of which the Druids were the consecrated interpreters. Possibly the woods, which the priests regarded as holy, had the property of producing real harmonies, like those of the Æolian harp. Such harmonious woods and musical trees are mentioned in many traditions of the olden time and reports of later times. Some soldiers, encamped in a valley in the Black Forest toward the end of the seventeenth century, heard charming sounds in the tops of the fir-trees, accompanied by the rustling of the wind as it blew through the narrow valley. A tradition of a similar music in a wood near Cithas, in the department of the Haute Saône, France, is confirmed by the testimony of an ear-witness, Désiré Monnier, author of "Traditions populaires comparées." The filao, a tree of the island of Bourbon, emits soft, melancholy tones when its slender boughs are shaken by the wind. An avenue of such trees is the source of wonderfully touching harmonies. The reeds and rushes of the island of Sylt, with their supple stems and interlaced roots, give forth, whenever the lightest wind is blowing, tones which are at times like whispers, like a subdued singing, or like a loud whistle. The wind, which in this case causes the root-fibers to be rubbed together and turns the limber stalks upon themselves, exerts a similar action on the innumerable thistles of the Hungarian steppes, where, as on the battle-field of Kapolna, mournful sounds, mingled with the soft soughing of the wind, are heard on still nights. The poets of all ages have sung of these sounds of nature; the literature of all nations abounds in fables and myths concerning them; they possibly suggested the first attempts to make musical instruments; and they have suggested to the great musical composers themes for many of the striking passages of their most successful works.—*Die Natur.*

THE ENGLISH PRECURSORS OF NEWTON.

II.

ROBERT HOOKE was born at Freshwater, in the Isle of Wight, July 18, 1635. Like Newton, he was a sickly child, and, like Newton too, his early years were distinguished and diverted by his singular mechanical ingenuity. He has left it on record that, having seen an old brass clock taken to pieces, he succeeded in constructing, in imitation of it, a wooden one that would, after a fashion, go; and about the same period he rigged out a miniature ship with ropes, pulleys, and masts, besides a contrivance to make it fire off some small guns while sailing across an adjacent haven; with what childish applause and self-gratulation, we are left to imagine. Nor did his sole gifts lie in this direction. His literary aptitude was beyond the common, and he showed a marked taste for music and painting. His education was as various as his talents. His father, who was minister of the parish, destined him for his own profession; but his infirm health precluded serious study, and it was consequently proposed to bind him apprentice to a watchmaker, or some similarly skilled artisan. After his father's death in 1648, his artistic tendencies so far got the upper hand, that we hear of him in the workshop of Sir Peter Lely, where, however, his occupation seems to have been nothing more æsthetic than color-grinding. Either this preliminary stage of art disgusted him, or (as his biographers prefer to state) the smell of oil-paint aggravated his constitutional headaches, and he was transferred to the care of Dr. Busby, the celebrated master of Westminster School, who kept him gratuitously in his own house for several years. Here his education, properly speaking, may be said to have begun. He not only acquired a competent knowledge of Latin and Greek, with a tincture of Hebrew and other Oriental languages, but is said to have astonished his teachers by mastering the first six books of Euclid in as many days, and by playing, without instruction, twenty lessons on the organ. In 1653 he entered Christ Church, Oxford, as servitor to a Mr. Goodman; and ten years later received, on the nomination of Lord Clarendon, then Chancellor of the University, the degree of Master of Arts, which his poverty had perhaps prevented him from taking in the ordinary course.

In 1654 the Hon. Robert Boyle, having finished his travels in Italy and his studies at Leyden, came to reside at Oxford. This amiable and ingenious gentleman has been quaintly panegyrized by an Irish humorist as "the father of chemistry and brother of the Earl of Cork." Although the clauses of this eulogy command different degrees of assent, and claim different kinds of esteem, they may be taken together as roughly summarizing the merits of its subject in the popular apprehension of that time. He was infected to an extraordinary extent with the prevailing experimental fervor, and contributed perhaps more than any of his contemporaries to advance the credit and promote the cultivation of science. The tinge of credulity which occasionally colored his inquiries may be excused (in the words of Bacon's apology for corruption) as *vitium temporis non hominis*, and we suppress a smile at his solemn testamentary disposition of an infallible recipe for "multiplying gold," when we find Newton and Locke the eager recipients of the secret.

Several members of the "Philosophical or Invisible College" of London finding themselves about this time together at Oxford, their discussions were resumed, and Hooke's singular mechanical skill quickly brought him to their notice. Boyle at once attached him to himself, and, if we are to believe what Anthony Wood tells us,* was glad to improve his foreign acquirements by receiving from the young servitor instruction in Euclid, and some much-needed light on the Cartesian philosophy. What is more certain is, that Hooke constructed for him an air-pump vastly superior in design to that recently contrived at Magdeburg by Otto Guericke, and differing in no essential particular from that now in use. He further devised thirty different modes of flying, and emulated Archytas in the production of a "Module" (we quote his own words), "which, by the help of springs and wings, raised and sustained itself in the air; but finding," he adds, "by my own trials, and afterward by calculation, that the muscles of a man's body were not sufficient to do anything considerable of that kind, I applied my mind to contrive a way to make artificial muscles, divers designs whereof I shewed also at the same time to Dr. Wilkins, then Warden of Wadham College, but was in many of my trials frustrated of my expectations." †

It may be conjectured that the failure of these attempts sufficed to convince the Icarus of Wadham of the impracticability of his projected lunar excursion, as well as to divert their author to less ambitious designs. The improvement of timepieces was then looked upon as the shortest road to the solution of the great practical problem of finding the longitude at sea, and in this direction, accordingly, Hooke next turned his thoughts and his experiments. He was rewarded by the discovery of a contrivance for applying springs to regulate the movement of watches. For this important invention his friends endeavored to procure him a patent, which he, however, refused, being dissatisfied with the terms proposed; and it thus remained undivulged, and by many disbelieved in. But when, in 1675, Huygens published, in the "Journal des Savants," his discovery of spiral watch-springs, Hooke indignantly claimed it as his own, incidentally attacking Oldenburg, then Secretary of the Royal Society, with whom he was never on very civil terms. A sharp paper-conflict ensued, Hooke (quite unjustifiably)

* "Athenæ Oxonienses," vol. iv., p. 628.

† "The Life of Dr. Robert Hooke," "Posthumous Works," p. iv.

accusing Oldenburg of "trafficking in intelligence," and Oldenburg retaliating with the better-founded assertion that Hooke's "pendulum-watches" could never be got to go; while Huygens, who might well disdain to wrangle over so small a prize, stood aloof, and let the controversy rage. Hooke's priority, as regards the principle, is unquestionable; but it is equally unquestionable that the modification introduced by Huygens first brought the improved timepieces into general use. That modification was nothing more than the coiling into a spiral of a spring which, in Hooke's design, had remained straight. So fine is the line drawn between failure and success.

The history of this invention is, in brief, the history of Hooke's life. He was a man whose brilliant qualities were neutralized one by the other. His extraordinary ingenuity was marred by his equally extraordinary versatility. His thoughts pursued each other in a rapid succession of vivid and original suggestions; but they found no halting-place on the way. He received them with rapture, but they wearied him if they staid too long. He welcomed all, but made none his friend. He wanted that laborious passion of perfection, apart from which the progeny of invention is but a sterile brood. His mind was like a telescope without clock-work, which shows the moving host of heaven, but can not fix or observe any individual star. Thus, his discoveries and investigations were usually abandoned or postponed when on the point of completion. It was not until some other inquirer, less discursive or more discreet, added the finishing touches still wanting, that he became sensible of the full value of what he had neglected, and, with loud vociferations, stood on the highway of learning, crying "Stop thief!" to the whole scientific world. Nor was his manner of conducting these controversies happier than his choice of occasions for them. His tone in argument was at all times dictatorial, and under excitement it was apt to become shrill. By his arrogance, he exasperated his adversaries; by his irritability, he prejudiced his cause. Thus, when (as not unfrequently happened) he was in the right, he roused animosity; when he was in the wrong, he incurred discredit.

But we anticipate our narrative. The foundation of the Royal Society opened to him the road to fortune and fame. Having raised his reputation by an able paper on "Capillary Attraction," his name was placed on the first list of Fellows, and on November 12, 1662, he was unanimously elected Curator of Experiments, "with the thanks of the Society ordered to Mr. Boyle for dispensing with him for their use." He had at this time entered on his twenty-ninth year, and had within him a spirit of fire, not indeed "grossly," but most inadequately "clad" in the corporeal "dimension" of his species. Pepys, who knew him well and rated him high, notes in his "Diary" that "Mr. Hooke is the most, and promises the least, of any man in the world that ever I saw." His personal appearance, indeed, was to the last degree deplorable. His figure was crooked, his limbs shrunken and emaciated, his aspect meager, his carriage stooping. He wore his hair, which was of a dark-brown color, hanging in long, disheveled locks over his face, and it was not until three years before his death that, conforming at last to the fashion of his time, he cut it off, and substituted a periwig. Up to the age of sixteen, he was said to have been straight, and he himself attributed his deformity to his excessive use when young of "incurvating exercises," such as working with a turning-lathe. Waller, his earliest biographer, tells us:

> His eyes were gray and full, with a sharp ingenious look while younger; his nose thin, but of a moderate height and length; his mouth meanly wide, and upper lip thin; his chin sharp and forehead large; his head of a middle size. . . . He went stooping and very fast, having but a light body to carry, and a great deal of spirits and activity, especially in his youth. He was of an active, restless, indefatigable genius even almost to the last, and always slept little to his death, seldom going to sleep till two, three, or four o'clock in the morning, and seldomer to bed, oftener continuing his studies all night, and taking a short nap in the day. His temper was melancholy, mistrustful, and jealous, which more increased upon him with his years. . . . He had a piercing judgment into the dispositions of others, and would sometimes give shrewd guesses and smart characters.*

The extreme parsimony, which the necessities of his early life had rendered a virtue, degenerated, as years went on, into a weakness if not into a vice. After his death, a large iron chest, which it appeared by evident signs had lain undisturbed for above thirty years, was discovered in his lodgings, and on being opened was found to contain several thousand pounds in gold and silver, accumulated by him in the lucrative employment of surveyor for the rebuilding of the city after the fire of September 3, 1666. Thus he condemned himself to a life of sordid privation, while relegating to dust and cobwebs a treasure which he was too penurious to spend, and too busy even to enjoy the miser's pleasure of counting.

It is difficult to convey an adequate idea of the multifarious and unceasing activity of Hooke's intellectual life during the forty years of his connection with the Royal Society. It reflected the boundless but fortuitous curiosity of an age which had indeed realized the bold vaunt of its herald, by leaving the pillars of Hercules of ancient lore far behind; but now found itself, like Ulysses of old, embarked on a trackless ocean without any sure pilotage to the happy isles of renovated science. Hooke and his contemporaries were inflamed with the unmeasured hopes and vast ambition of the Verulamian prophecies; but they began to be more and more conscious that the Verulamian method was but as the "golden path of rays" leading to the setting sun. They were haunted by the idea that Nature was to be interrogated, not progressively or by installments, but once for all, by a supreme inductive effort,† and they could not wholly relinquish the hope that they were destined to witness its consummation. They had been

* "Life," p. xxvii. † Bacon, preface to the "Parasceve," "Works," vol. i., p. 394.

told to expand their souls to the measure of the universe, and they were unwilling to confess their inadequacy to the effort required of them. They were like men groping in the darkness for a door which they had but to throw wide, in order to find themselves in the full blaze of daylight; and they learned with reluctance that only by painful and prolonged exertions could they expect to open a chink here and there for a ray of twilight to enter.

This insensible change of front, as regards scientific method, is very clearly discernible in Hooke's writings. He began life with hopes as large as and more defined than those of Bacon himself. Even before he left Oxford, he had provided himself with what he called a "mechanical algebra," which he regarded as an infallible guide to invention. This he afterward expanded into an elaborate engine of discovery, competent, as he believed, to construct with certainty and swiftness an edifice of knowledge, heretofore unmatched for vastness and durability. The scheme, like all his more ambitious designs, remained incomplete, or, at most, was completed only in the mind of its author; and the tract in which he describes it breaks off just as the momentous secret is about to be disclosed. Whether it was that the difficulties in the way became more clear to him as he advanced, and that he lost faith in his own means of removing them, or whether it was that his jealousy of disclosure overbalanced, at the critical moment, his appetite for fame, we shall never know. We do know, however, enough to show us that the revelation would have been valuable only as a gratification of our curiosity, and as throwing a singular light on the visions which haunted the morning of experimental science.

The following extract from his essay on "The Present State of Natural Philosophy" briefly exposes his ideal of a method. He attempted, as will be seen, to come to closer quarters with the problem than Bacon had done, and succeeded thereby in more clearly defining its insolubility.

> "Some other kind of art for inquiry," he writes,* "than what hath been hitherto made use of, must be discovered; the intellect is not to be suffered to act without its helps, but is continually to be assisted by some method or engine, which shall be as a guide to regulate its actions, so as that it shall not be able to act amiss. Of this engine, no man except the incomparable Verulam hath had any thoughts, and he indeed hath promoted it to a very good pitch; but there is yet somewhat more to be added, which he seemed to want time to complete. By this, as by that art of Algebra in Geometry, 'twill be very easy to proceed in any natural inquiry, regularly and certainly: and indeed it may not improperly be called a Philosophical Algebra, or an art of directing the mind in the search after philosophical truths."

The first part only of this "Algebra of Discovery," "containing the manner of preparing the mind, and furnishing it with fit materials to work on," was written; the second, which should have set forth "the

* "Posthumous Works," p. 6.

rules and methods of proceeding and operating with this so collected and qualified Supellex," remained in embryo. Hooke, like Bacon, set out with a classification of the errors incidental to humanity in its actual condition; but his mode of rectifying them was a more patient and practical process than the "expurgation of the intellect," preached by the philosophic Chancellor. The senses are to be helped, he tells us, by skillfully constructed instruments, whereby their sphere of action may be enlarged, and their untutored impressions brought to the test of exact measurement and rigid calculation. The report of one sense must be corrected by comparison with that of the others, until "sensation is reduced to a standard," and the mind is gradually informed with true notions of "things, as they are part of, and actors or patients in the universe, not only as they have this or that peculiar relation or influence on our own senses or selves."

The next step in the "Preparation" consisted in the compilation of a "Philosophical History," comprising—

> A brief and plain account of a great store of choice and significant natural and artificial operations, actions, and effects, ranged in a convenient order, and interwoven here and there with some short hints of accidental remarks or theories, of corresponding or disagreeing received opinions, of doubts and queries, and the like; and, indeed, until this repository be pretty well stored with choice and sound materials, the work of raising new axioms or theories is not to be attempted, lest beginning without materials the whole design be given over in the middle.*

The matter of such a history, he says further, is no less than the world; "for there is no body or operation in the universe that is not some way or other to be taken notice of in this great work." And the programme which he proceeds to lay down in no way belies his promise. Fire, air, earth, and water, light and darkness, heat and cold, gravity and levity, all the "prime sensible qualities" of nature, find each its place in this stupendous magazine of knowledge. From ether to anthracite, from a man to a mite or a mushroom, from dreams and influences to arts and sciences, from the starry firmament to the costermonger's cart or the cobbler's stall, no substance, quality, or accident is excluded. No natural process, no commercial product, but has its separate "History." The despised handicraftsman is to yield up his obscure secrets as well as the scientific artisan. A Dollond or a Steinheil is not more stimulating to the catholic curiosity of the natural historian than a Quince, a Bottom, or a Snug. Yet all this encyclopedic mass of information, infinite in its subject, indefinite in its extent, expansive in its nature, Hooke tells us he "has very good reason to believe may be contained in much fewer words than the writings of divers single authors!" † This would, indeed, have been to imprison the liberated genius of knowledge within narrower limits than those

* "Posthumous Works," p. 18.

† Ibid., p. 21.

of Aristotelian tradition. The seal, however, was broken; the vase was already at the bottom of the sea, and it only remained to guide and propitiate a power which it was no longer possible to confine.

The "Philosophical History," of which Hooke traced the gigantic plan, would, in fact, have included what we now understand as the whole body of inductive science, with a considerable margin of heterogeneous material, difficult of classification, and more curious, perhaps, than useful. It would have included not only an enumeration of all possible phenomena, but the knowledge of the laws by which they are governed, and the causes by which they are produced. The natural historian was to be "knowing in hypotheses," that he might set his facts in plausible sequence of cause and effect; he was to be a skilled mechanician, and an able mathematician, that he might investigate their relations by experiment, and deduce the consequences of such relations by calculation. Hooke's "Helps of Discovery" are but another form of Bacon's "Prerogative Instances"; but it is significant that in the later system they appear in the preparatory stage, while in the earlier they form an integral part of the "Organum" itself. The impossible was, in fact, relegated to a distant future, while the possible took possession of the present. The "raising of axioms," and the discovery of "forms," which were supposed to constitute the true business of the philosopher, were postponed in favor of the more modest task of setting facts in order, and connecting them by means of ideas. Thus natural philosophy, in the recondite sense in which it was understood by the theorists of the seventeenth century, came, as time went on, to be more and more fully personated by her handmaiden, "Natural History," until at last the identity of the one was completely merged in that of the other. The intermediary whom they had admitted as a messenger of higher promise, they were compelled to take for better for worse. Like Malvolio, they had wooed the mistress; like Sir Toby, they wedded the maid.

We shall conclude our remarks on this singular essay by transcribing some specimens of the queries directed by Hooke to future investigators. Even after the lapse of above two centuries, they strike us as suggestive and ingenious. Under the heading of "Ether," he asks:

Whether it permeates all bodies, be the medium of light, be the fluid body in which the air is but as a tincture? Whether it cause gravity, in the earth or other celestial bodies?

Of the atmosphere:

Whether it encompasses the sun and planets, and that each of them have a peculiar atmosphere, as well as they have a gravitating power?

Whether the spots in the sun may not be clouds of smoke or vapors, raised up into that atmosphere?

Whether meteors have anything of fire in them, or whether the light may not be an effect of their rapid motion?

Although Hooke's "True Method" was not published until after his death, we may safely attribute it to an early stage of his career. He was a man whose ideas did not change, but were superseded. They retained their original form, but were crowded out of sight by the multitude of new arrivals. Now we have evidence to show that, without wholly abandoning his early faith in the efficacy of his "Philosophical Algebra," his confidence in an approaching renovation of science was replaced, later in life, by a conviction of its infinite complexity and extent. In the preface to a volume of "Lectures," published in 1674, he says: *

> For as there is scarce one subject of millions that may be pitched upon, but to write an exact and complete history thereof would require the whole time and attention of a man's life, and some thousands of inventions and observations to accomplish it: so on the other side no man is able to say that he will complete this or that inquiry, whatever it be (the greatest part of invention being but a lucky hit of chance, for the most part not in our own power). 'Twill be much better, therefore, to embrace the influences of Providence, and to be diligent in the inquiry of everything we meet with. For we shall quickly find that the number of considerable observations and inventions this way collected will a hundredfold outstrip those that are found by design. No man but hath some lucky hits and useful thoughts on this or that subject he is conversant about, the regarding and communicating of which might be a means to other persons highly to improve them. . . . This way is also more grateful both to the writer and the reader, who proceed with a fresh stomach upon variety, but would be weary and dull'd if necessitated to dwell too long upon one subject.†

Thus we see that discovery, which speculation had proclaimed to be the infallible result of system, was by experience declared to be the lucky outcome of chance. Investigators had previously been commanded to march in a compact army along the highway of method toward the metropolis of knowledge; they were now warned to disperse in all possible directions into the wilderness of phenomena, and beat the bushes of nature for what game they might contain. That one view was equally misleading with the other is obvious; that one should form the reaction from the other was inevitable. Hooke's reasons for discursiveness were not so much the guide of his conduct as its apology. His position as Curator of Experiments to a body inordinately greedy of scientific novelty suggested a wide range of subjects for inquiry, which his native versatility induced him to embrace to its fullest extent. The journals and registers of the Royal Society alone convey, by their records, an adequate idea of his prodigious activity of mind, fertility of resource, and experimental skill. Astronomy, optics, acoustics, thermotics, pneumatics, hydrostatics, magnetism, and chemistry; geology, physiology, meteorology, and psychology—all in turn engaged his attention, and all in turn received illustrations from

* "Posthumous Works," p. 29.

† "An Attempt to prove the Motion of the Earth," London, 1674.

his sagacity, and impulses from his zeal. Of all men who ever lived, he was perhaps the most prolific in mechanical invention. New instruments, or useful modifications of those already in use, flowed from him by the dozen. An arithmetical machine, a triple writing-machine, a deep-sea sounding machine, a wind-gauge, rain-gauge, hygrometer and odometer, a system of telescopic telegraphy, a "water-poise," a "weather-clock," and a species of microphone, were all due to his ingenuity; besides important improvements in astronomical and other instruments —telescopes, quadrants, micrometers, diving-bells, barometers, thermometers, and balances. He speculated curiously on memory, and calculated the number of ideas of which the human mind is susceptible, estimating it at three thousand one hundred and fifty-five million seven hundred and sixty thousand! He constructed a model for the rebuilding of London after the great fire, which was approved, although not adopted; and was the architect of Hoxton Hospital and other buildings. He read before the Royal Society commentaries on Ovid's "Metamorphoses," Plato's "Atlantis," and Hanno's "Periplus," interpolating these critical excursions between geological theories and astronomical observations. To him was due the ingenious idea of measuring the force of gravity at different altitudes by the rate of vibration of a pendulum of a given length; as well as the determination (so far as the actual state of chemical knowledge permitted it to be determined) of the true function of the air in combustion and respiration. His zeal carried him to the length of making, in an exhausted receiver, his own person the subject of his observations—"the only experiment of that kind," his biographer naïvely remarks, "I think ever tried."

At the present time, when weather prophecies have come to form a recognized part of our complex social machinery, it would be ungrateful to omit noticing that Hooke was the first to propose a scientific system of meteorological forecasting. His scheme, as might be expected, had for its basis the close association (remarked by him among the earliest) of changes of weather with barometrical variations; which, he writes to Boyle, October 6, 1664—

> If it continue to do as I have hitherto observed it, I hope it will help us one step toward the raising a theorical pillar or pyramid, from the top of which, when raised and ascended, we may be able to see the mutations of the weather at some distance, before they approach us; and thereby being able to predict and forewarn, many dangers may be prevented, and the good of mankind very much promoted.*

The means recommended by him for the furtherance of this noteworthy object were the same in principle as those now in use at all the meteorological observatories of Europe and America. Two hundred years, however, had to elapse before they could be profitably employed.

* Boyle's "Works," vol. vi., p. 492.

In his "Method for making a History of the Weather,"* the attention of observers is especially directed to the following "particulars," as "requisite for the raising of axioms whereby the cause or laws of weather may be found out": 1. The strength and quarter of the winds. 2. The degrees of heat and cold. 3. The degrees of dryness and moisture observed with a hygroscope "made with the single beard of a wild oat perfectly ripe, set upright and headed with an index." 4. The degrees of pressure of the air. 5. The constitution and face of the sky.

It is perhaps worth remarking that our present system of meteorological observations corresponds with tolerable accuracy to Bacon's notion of how a "history" of any special branch of physics should be compiled; with this difference in result, that, instead of arriving at "axioms" and "forms," we have as yet obtained only a set of empirical rules which, however practically useful, can scarcely be said to constitute a science.

"Discoursed with Mr. Hooke," Pepys wrote, August 8, 1666, "about the nature of sounds, and he did make me understand the nature of musicall sounds made by strings, mighty prettily; and told me that having come to a certain number of vibrations proper to make any tone, he is able to tell how many strokes a fly makes with her wings (those flies that hum in their flying) by the note that it answers to in musique, during their flying. That, I suppose, is a little too much refined, but his discourse in general of sound was mighty fine."†

Notwithstanding Mr. Pepys's skepticism, Hooke was on this occasion not "refining" overmuch. He exhibited in 1681 an instrument (with the principle of which he had doubtless long been acquainted) for counting the pulsations of sound, which seems to have been virtually identical with that now known as "Savart's Wheel." He also anticipated Chladni's celebrated experiment by strewing flour on a vibrating glass bell, thus presenting to the eye, as it were, a picture of the configuration of rest and motion on its surface. It was one of his favorite ideas that, by some future discovery, the sense of hearing would be reënforced as prodigiously as the sense of sight had already been by the telescope—an intuition singularly realized by the recent invention of the telephone. "It has not yet been thoroughly examined," he wrote in 1664,‡ "how far Otocousticons may be improved, nor what other ways there may be of quickening our hearing, or conveying sound through other bodies than the air." "By very casual trials," he tells us elsewhere, he had made some progress in this direction, and was by no means convinced that they might not be prosecuted so far as to render audible noises made at the distance of the planets! Although acknowledging that to his own prejudices this seemed "a very extravagant conjecture, . . . yet methinks," he adds, "I should have

* Published by Sprat, "History of the Royal Society," p. 173.

† Pepys's "Diary," vol. iv., p. 43, Bright's edition. ‡ "Micrographia," preface.

had the same thoughts of a conjecture to find out a help for the eye to see the smaller parts and rocks of the moon," and "would fain persuade myself against concluding or building on the impossibility of such things as I am not able demonstrably to prove not possible." *

Of Hooke's private and personal history there is little to be recorded. His life might almost be comprised in two words—experiments and controversies. In 1664 Sir John Cutler instituted, especially for his benefit, a mechanical lecturership of fifty pounds a year; in the following year he was appointed to the professorship of Geometry † founded by Sir Thomas Gresham in 1575. His services as curator were remunerated by an annual stipend of thirty pounds, not perhaps very regularly paid, since we hear, on one occasion, that both he and Halley were offered, in lieu of their respective salaries, an equivalent number of copies of that unlucky "History of Fishes," by the publication of which the Royal Society had drained their finances and cumbered their shelves. The famous controversy between Hooke and Hevelius on the subject of plain or telescopic sights, which agitated the learned world of Europe during many years, has long ago sunk into a silence we need not disturb. Hevelius was in the wrong, and obstinate; Hooke was in the right, but offensive. Astronomers in general seemed disposed to prefer some slight uncertainty as to the position of the stars, to being bullied into precision by the magisterial little hunchback of Gresham College. The dispute remained long in the condition of a smoldering flame, with outbreaks of argument at distant intervals, and Halley's mission of conciliation in 1679 helped to soothe the vanity of the irritated philosopher of Dantzic, but did not tend to rectify his method.

We now come to the relations of Hooke with Newton. The first collision between these two remarkable men occurred on the subject of their respective optical discoveries. Hooke's merits in this direction were very considerable. He was the first to propound that view as to the nature of light now universally accepted under the name of the "undulatory theory." He held that light is a "very short vibrative motion," originating in an agitation of the minute particles of the luminous body, and propagated through a perfectly homogeneous and elastic medium "by direct or straight lines, extended every way, like rays from the center of a sphere, . . . just after the same manner (though indefinitely swifter) as the waves or rings on the surface of the water do swell into bigger and bigger circles about a point of it, where by the sinking of a stone the motion was begun." ‡

Further, he hit upon the principle of "interference," which, neg-

* "Of the True Method of building a Solid Philosophy," "Posthumous Works," p. 39.

† Hooke read the "Gresham Lectures on Astronomy" in 1664–'65, during the absence in Italy of Professor Pope; but never occupied that chair except as *locum tenens*.

‡ "Micrographia," pp. 56, 57.

lected by Huygens and ignored by Newton, was destined, in the hands of Young and Fresnel, to afford demonstrative proof of the truth of the hypothesis roughly sketched by Hooke. In his "Micrographia" (justly styled by Pepys "a most excellent piece") he described, besides a series of beautiful observations with the microscope, the phenomenon known in optical treatises as the "colors of thin plates," and with singular sagacity declared it to form the *experimentum crucis* as regards chromatic light. These "fantastical" tints (which we may recognize every summer's day in the iridescent glancing of some insect's wing) Hooke diligently examined in soap-bubbles, in "muscovy-glass" (mica), in metallic films, and other similar substances. His explanation of what he observed contains a remarkable, although necessarily imperfect, approximation to a cardinal truth in optics. By a double reflection from two closely adjacent surfaces, he tells us,* the rays of light are broken up into "confused or duplicated pulses," changing in tint with the varying thickness of the reflecting film. Thus, "colors begin to appear, when the pulses of light are blended so well and so near together that the sense takes them for one."† According to the modern doctrine of "interference," waves of light, pursuing each other at the distance of half an undulation, mutually destroy each other, and produce darkness. But, because difference of color means difference of wave-length, a doubly-reflecting surface, by destroying or reënforcing, according to its varying thickness, undulations of certain lengths, analyzes white light into the prismatic rays of which it is composed, and thus produces the appearances characteristic of "thin plates."

The flaw in Hooke's theory was his erroneous idea as to the nature of color. And on this point we are unable to defend him from the charge of culpable ignorance. The true view was proposed to him, and he deliberately rejected it. The keystone of the arch he had attempted to build was offered to him, and he declined to set it in its place. On February 8, 1672, Newton's memorable paper on the composition of white light was read before the Royal Society. Had Hooke frankly accepted the discovery, and applied it as a bulwark to his own tottering hypothesis, his name would doubtless have sounded louder in the ears of posterity. But here his moral failings, as well as his intellectual shortcomings, interposed. He was, primarily, an experimentalist. His delight was rather in the things than in the thoughts of Nature. The intimate relations of objects were of less account in his eyes than their external operation on the senses. Add to this the utilitarian tendency impressed upon physical researches by the Baconian precepts. In the preface to the "Micrographia" Hooke described as follows the purposes of the Royal Society: "They do not wholly reject experiments of mere light and theory, but they principally aim at such, whose application will improve and facilitate the present way of manual arts." And similar declarations were made by Boyle and

* "Micrographia," p. 66. † "Posthumous Works," p. 190.

other leading men of the time. Thus, in Hooke's apprehension, the *raison d'être* of an hypothesis was not so much to suggest a physical connection of facts as to provide a convenient classification of experiments, and its most essential quality that it should be plausible, not that it should be true.

His judgment was besides warped, even more than that of most men, by that intellectual egotism which, if it sometimes acts as a spur to progress, more often performs the office of a drag. His self-love blinded him to the real merits of his competitors. His own speculations loomed so large before him as to exclude from his field of view those of every other. Newton acknowledged that, if he saw farther than most men, it was "by standing on the shoulders of giants." Hooke thought his own mental stature sufficient to entitle him to reject such extraneous aids. He accordingly set aside without hesitation Newton's discovery, offering his criticisms, not indeed discourteously, but with a certain air of superiority which not a little galled his sensitive antagonist. Matters were aggravated three years later when Newton published his beautiful explanation, on the emission hypothesis, of the colors of thin plates. Hooke declared that "the main of it was contained in the 'Micrographia,'" a remark extremely offensive to Newton, who, however, with his usual careful justice, immediately extended his somewhat scanty acknowledgment of his rival's labors, by defining with scrupulous accuracy the measure in which he was indebted to him. That Hooke was not devoid of generous sentiments appears from a letter which he wrote about this time to Newton, proposing a private correspondence on philosophical subjects.* In it he acknowledges the superior abilities of the great mathematician, professes a dislike to contention, and hints that their relations had been embittered by the machinations of ill-disposed persons. (Oldenburg is evidently indicated.) Newton's reply was conceived in a corresponding spirit; but the harmony thus established was unhappily not lasting.

The problem of gravity was the supreme question of that time. It stood first among the orders of the day of the scientific council. It was instinctively felt that, until it should be disposed of, no real progress could be made in physical knowledge. And, slowly but surely, the way was being prepared for a great discovery. Galileo had made Newton possible. Men's ideas were gradually clarifying; the great cosmical analogies, now so familiar, were step by step emerging out of the dusk of ignorance; antiquated prepossessions were sinking, in a sediment of cloudy cavil, out of sight. Heaven was assimilated to earth, and earth to heaven; the old gratuitous separation between the starry firmament over our heads and the solid globe under our feet was abolished by acclamation, and it was felt that the coming law, to be valid, must embrace in its operation the whole of the visible uni-

* Brewster, "Life of Newton," vol. i., p. 138.

verse. Toward this consummation Gilbert contributed something by his theory of universal magnetism; and Galileo, as well as Bacon and Horrocks, foresaw that in this direction lay the coveted secret. In 1645 the Abbé Boulliau (Bullialdus) actually announced* that the force by which the sun holds the planets in their orbits must vary as the inverse square of their distance from him; in 1666 Borelli published at Florence some suggestive speculations on the subject; † in England, Wallis, Wren, and Halley, all eagerly scanned the question, and all arrived at close approximations to the truth. But it was undoubtedly Hooke whose arrow flew nearest to the mark. The first definite proposal of the planetary revolutions as a problem in mechanics is due to him; and it has been immemorially held that *prudens quæstio est dimidium scientiæ.* In a paper on "Gravity," presented by him to the Royal Society, March 21, 1666, the following noteworthy passage occurs:

> If such a principle (central attraction) be supposed, all the phenomena of the planets seem possible to be explained by the common principle of mechanic motions; and possibly the prosecuting this speculation may give us a true hypothesis of their motion, and, from some few observations, their motions may be so far brought to a certainty that we may be able to calculate them to the greatest exactness and certainty that can be desired.‡

On this matter, at least, Hooke's ideas were persistent and progressive. In 1674 he announced a forthcoming "system of the world, answering in all things to the common rules of mechanical motions," and founded on the three following suppositions:

> 1. That all celestial bodies whatsoever have an attraction or gravitating power towards their own centres, whereby they attract not only their own parts . . . but also all the other celestial bodies that are within the sphere of their activity. 2. That all bodies whatsoever that are put into a direct and simple motion, will so continue to move forward in a straight line till they are, by some other effectual powers, deflected and sent into a motion describing a circle, ellipsis, or some other more compounded curve line. 3. That these attractive powers are so much the more powerful in operating by how much the nearer the body wrought upon is to their own centres. Now, what these several degrees are, I have not yet experimentally verified, but it is a notion which, if fully prosecuted, as it ought to be, will mightily assist the astronomer to reduce all the celestial motions to a certain rule, which I doubt will never be done without it. But this I durst promise the undertaker, that he will find all the great motions of the world to be influenced by this principle, and that the true understanding thereof will be the true perfection of astronomy.§

Our readers will perceive that he was at this time still at fault as to the rate of decrease of the central force; but, some years later, this

* "Astronomia Philolaica," Paris, 1645.

† "Theoricæ Mediceorum Planetarum," Florence, 1666.

‡ Birch, "The History of the Royal Society," vol. ii., p. 91.

§ "An Attempt to prove the Motion of the Earth," p. 28.

too was divined by him—divined, not demonstrated. In 1679 he wrote to Newton, suggesting the law of inverse squares, or "reciprocal duplicate proportion," and it was this letter which led the Cambridge philosopher to "resume his former thoughts concerning the moon." * He first, as is well known, attempted the problem of assimilating the force of gravity at the earth's surface to the deflecting power exerted on the moon's orbital motion, in 1665, when he "gathered" the duplicate proportion from Kepler's third law; but the defective *data* then at his command obliged him to suspend his speculations. Now, with the results of Picard's improved degree measurement in his hands, he once more set his gigantic powers to their equally gigantic task. Having made some progress with the calculations, he, however, again "threw them by, being upon other studies" †; and it required a further fillip to induce him to complete them. It was given thus:

One January day in 1684, Edmund Halley, a young and rising astronomer, having independently worked out the great problem so far as to perceive the necessity for the ratio of inverse squares, came to town from Islington, and, falling into discourse with Wren and Hooke on the subject, the latter "affirmed that upon that principle all the laws of the celestial motions were to be demonstrated, and that he himself had done it. I declared," continues Halley,‡ "the ill-success of my attempts, and Sir Christopher, to encourage the enquiry, said that he would give Mr. Hooke some two months' time to bring him a convincing demonstration thereof, and besides the honour, he of us that did it should have from him a present of a book of forty shillings. Mr. Hooke then said he had it, but should conceal it for some time, that others trying and failing might know how to value it when he should make it public. However, I remember that Sir Christopher was little satisfied that he could do it, and though Mr. Hooke then promised to show it him, I do not find that in that particular he has been so good as his word."

The two months' interval allowed by Wren for the production of the desired solution elapsed four times over, and Hooke made no sign. Then, at last, Halley started for Cambridge, and laid the difficulty before Newton. In after-life he was accustomed to boast that "he had been the Ulysses who produced this Achilles." § For the result of his visit was the "Principia."

The most painful passage in Hooke's life now comes before us. When the first book of his rival's immortal work was, on April 28, 1686, received by the Royal Society with the applause which it deserved, he was unable to restrain his jealous disappointment within the bounds of moderation or decency. He quarreled with the Presi-

* Brewster, "Life of Newton," vol. i., p. 291.

† Letter to Halley, quoted by Brewster, vol. i., p. 292.

‡ Letter to Newton, quoted by Brewster, vol. i., p. 293, note.

§ Brewster, "Life of Newton," vol. i., p. 298.

dent for overlooking his prior claims; he endeavored to persuade the members that Newton was indebted to him for the first hint of a discovery which he pretended was but a small part of what he himself had conceived, and was engaged in perfecting; he did not attempt to conceal that he regarded Newton's triumph in the light of a personal injury. When this "strange carriage" was reported (probably with some exaggeration) to Newton, he was, not unreasonably, incensed, and wrote to Halley concerning it in somewhat acrimonious terms. Halley, who seems to have acted throughout a very creditable part, replied by urging that Hooke's conduct had been represented in worse colors than it deserved; whereupon Newton not only expressed his regret for the angry "postscript to his last," but agreed, with the view of "composing the dispute," to insert into the text of his book the following acknowledgment:

"The inverse law of gravity holds in all the celestial motions, as was discovered also independently by my countrymen, Wren, Hooke, and Halley."*

How far Hooke was pacified by this concession does not appear; but there is evidence that he continued, although in a lower key, to claim ownership in the discovery of gravity. It was, indeed, difficult for him to see with equanimity the great scientific prize of the century, which he had set before him as the crowning glory of his own career, carried off before his eyes by a swifter competitor; and he could not be expected to recognize, what to us is evident enough, that his powers were wholly unequal to the unique achievement of his rival. The intuition of a discovery is one thing, its demonstration another; and, while the one excites our interest and curiosity, it is to the other that we justly apportion our unqualified admiration.

Between Hooke and Newton no further intercourse seems at any time to have been set on foot. If Hooke was jealous of Newton, Newton was perhaps somewhat ungenerous toward Hooke. He recognized his merits with reluctance, and acknowledged his inventions only by compulsion. Broils and disquietudes, and the fomentors and originators thereof, were in truth odious to him; and he was at all times disposed to conceal a discovery, rather than risk a controversy. "Philosophy," he wrote to Halley,† "is such an impertinently litigious lady, that a man had as good be engaged in lawsuits as have to do with her." Thus the turmoil raised by Hooke on the appearance of the first part of the "Principia" inspired him with so deep a disgust that he seriously contemplated suppressing the remainder; and he could never be induced to publish his work on "Optics" until the death of his unquiet opponent had secured for it a peaceful reception. But the most significant fact as regards the relations of these two men is that Newton,

* Scholium to the Fourth Proposition in First Book of "Principia." Brewster, "Life of Newton," vol. i., p. 311.

† Letter of June 20, 1686, "Biographia Britannica," article "Halley."

who, during Hooke's lifetime had never sat at the council-table of the Royal Society, was, only a few months after his decease, elected both to that position and the still higher one of President, on the same day, November 30, 1703.

Not much now remains to be said. Hooke's growing infirmities of mind and body condemned him to isolation; and isolation is the chosen ally of eccentricity. Repeated disappointments had aggravated the inherent moroseness of his disposition; increasing ill health soured his naturally irritable temper; and the death, in 1687, of his niece, Mrs. Grace Hooke—probably the only person in the world for whom he entertained a sincere attachment—broke the last link uniting him to every-day humanity. Still he pursued his investigations with a feverish energy that age and sickness seemed rather to stimulate than to quell. His jealousy of piratical appropriation increased, with advancing years, almost to a mania; he enveloped his researches in a mysterious reserve; and many of the discoveries which he professed to have made, descended with him into the grave. Among these were a means of finding the longitude at sea, and a secret for perfecting all kinds of optical instruments. It might be conjectured, from the small size of some telescopes used by him, that this latter invention approached that of achromatism (made by Dollond in the middle of the following century); but, on the other hand, we find him laying it down as an axiom that increased power could only be obtained by increased focal length; and he is even said to have entertained as a possibility the construction of an instrument ten thousand feet long, which should bring into view the inhabitants of the moon! We can not, indeed, take his own word for his performances. He was probably not deliberately untruthful; but he was sanguine as well as vain, and apt to discourse largely of results, toward which imagination pointed, but which reason had not yet grasped. The Royal Society, at any rate, so far believed his professions as to make him, in 1696, a grant for the purpose of completing his researches and recording his discoveries. The remaining years of his life and his failing physical powers were dedicated, with almost insane zeal, to the task of raising an adequate monument to his experimental genius. Disease was powerless to divert him from his purpose; fatigue never seemed to approach him. Day after day, and night after night, he meditated, experimented, invented. For several years before his death, he was said never to have undressed or gone to bed. His limbs swelled, his brain reeled, his very eyesight failed; but still he worked, and wrote, and dreamed of immortality. At length a summons came which he was powerless to resist. He died on March 3, 1703, unloved, unlamented, and, at least in his own apprehension, unrecognized. He died, as he had lived, haunted by unfulfilled hopes, and deluded with abortive projects. In the midst of voluntary destitution, he had cherished a magnificent design for the endowment of the Royal Society. But he left no testamentary disposition of his hoarded wealth, which proved as barren after his death as it had been during his life.

Imprisoned in his own egotism, he did not know how to contribute his quota generously to the long day's labor of humanity. He sought to set his trade-mark on every thought. He would have desired a patent of protection for every experiment. His work was in consequence visited with the curse of sterility. A slave to *meum* and *tuum*—in his own words, "the great rudder of human affairs"—his peevish reclamations were met with the inexorable *Sic vos non vobis* of ironical destiny. Of the innumerable inventions which he originated, scarcely one has been associated with his name. His suggestions bore fruit in the hands of others. His ideas were appropriated and perfected by his rivals. His experiments conferred luster on his successors. By tacit consent, his intellectual inheritance was divided, and his claims ignored. Newton took up the theory of light where he abandoned it, and left him far behind in the momentous search for the law of gravitation. Mayow carried forward the investigations which he had set on foot as to the purpose subserved by the air in respiration.* His method was used by Picard in 1670, with striking success, in his new measurement of the earth. His observations formed the basis upon which Bradley founded, in 1728, his discovery of the aberration of light. That his repeated disappointments and mischances were in any degree attributable to his own deficiencies, naturally did not occur to him. It was simpler and more consolatory to set them down to the prevalent malignity and injustice of mankind. Hence the deepening shade of misanthropy which enveloped in saturnine reserve the later years of his life.

Nevertheless, Hooke was, in spite of conspicuous defects, by no means a bad man. His morals were irreproachable, his diligence was untiring, and his religious sentiments seem to have been unfeignedly devout. His faults were warpings of the mind, closely dependent, perhaps, on his unfortunate physical constitution. In spirit, as well as in person, Nature had set him somewhat awry. "Certainly," writes Bacon, "there is a consent between the body and the mind; and where Nature erreth in the one, she ventureth in the other. *Ubi peccat in uno, periclitatur in altero*." It was his misfortune that he could neither win sympathy nor inspire pity. His talents earned for him patronage; but his peculiarities repelled friendship. He lived sixty-eight years without attaching to himself a single human being, and died only to make room for his rival. And yet his intellectual qualities did not demand admiration more than his moral failings claimed tenderness. For surely infirmity has been rarely combined with genius in more painful and pitiable guise than in Robert Hooke.—*Edinburgh Review.*

* For an interesting account of Mayow's experiments, see Miss Buckley's "Short History of Science," p. 131.

CRITICISMS CORRECTED.

By HERBERT SPENCER.

I. TAIT AND KIRKMAN.

ONE way of estimating the validity of a critic's judgments is that of studying his mental peculiarities as generally displayed. If he betrays idiosyncrasies of thought in his writings at large, it may be inferred that these idiosyncrasies possibly, if not probably, give a character to the verdicts he passes upon the productions of others. I am led to make this remark by considering the probable connection between Professor Tait's habit of mind as otherwise shown and as shown in the opinion he has tacitly expressed respecting the formula of evolution.

Daily carrying on experimental researches, Professor Tait is profoundly impressed with the supreme value of the experimental method; and has reached the conviction that by it alone can any physical knowledge be gained. Though he calls the ultimate truths of physics "axioms," yet, not very consistently, he alleges that only by observation and experiment can these "axioms" be known as such. Passing over this inconsistency, however, we have here to note the implied proposition that, where no observation or experiment is possible, no physical truth can be established; and, indeed, that in the absence of any possibility of experiment or observation there is no basis for any physical belief at all. Now, "The Unseen Universe," a work written by him in conjunction with Professor Balfour Stewart, contains an elaborate argument concerning the relations between the universe which is visible to us and an invisible universe. This argument, carried on in pursuance of physical laws established by converse with the universe we know, extends them to the universe we do not know: the law of the conservation of energy, for example, being regarded as common to the two, and the principle of continuity, which is traced among perceptible phenomena, being assumed to hold likewise of the imperceptible. On the strength of these reasonings, conclusions are drawn which are considered as at least probable: support is found for certain theological beliefs. Now, clearly, the relation between the seen and the unseen universes can not be the subject of any observation or experiment; since, by the definition of it, one term of the relation is absent. If we have, then, no warrant for asserting a physical axiom save as a generalization of results of experiments—if, consequently, where no observation or experiment is possible, reasoning after physical methods can have no place—then there can be no basis for any conclusion respecting the physical relations of the seen and the unseen universes. Not so, however, concludes Professor Tait. He thinks that, while no validity can be claimed for our judgments respecting perceived forces, save as experimentally justified, some validity can be claimed for our judgments respecting unperceived forces, where no experimental justification is possible.

The peculiarity thus exhibited in Professor Tait's general thinking is exhibited also in some of his thinking on those special topics with which he is directly concerned as a Professor of Physics. An instance was given by Professor Clerk-Maxwell when reviewing, in "Nature," for July 3, 1879, the new edition (1879) of Thomson and Tait's "Treatise on Natural Philosophy." Professor Clerk-Maxwell writes: "Again, at page 222, the capacity of the student is called upon to accept the following statement: 'Matter has an innate power of resisting external influences, so that every body, as far as it can, remains at rest or moves uniformly in a straight line.' Is it a fact that 'matter' has any power, either innate or acquired, of resisting external influences?" And, to Professor Clerk-Maxwell's question thus put, the answer of one not having a like mental peculiarity with Professor Tait must surely be—No.

But the most remarkable example of Professor Tait's mode of thought, as exhibited in his own department, is contained in a lecture which he gave at Glasgow when the British Association last met there (see "Nature," September 21, 1876)—a lecture given for the purpose of dispelling certain erroneous conceptions of force commonly entertained. Asking how the word force "is to be correctly used," he says: "Here we can not but consult Newton. The sense in which he uses the word 'force,' and therefore the sense in which we must continue to use it if we desire to avoid intellectual confusion, will appear clearly from a brief consideration of his simple statement of the laws of motion. The first of these laws is: *Every body continues in its state of rest or of uniform motion in a straight line, except in so far as it is compelled by impressed forces to change that state.*" Thus Professor Tait quotes, and fully approves, that conception of force which regards it as something which changes the state of a body. Later on in the course of his lecture, after variously setting forth his views of how force is rightly to be conceived, he says, "Force is the rate at which an agent does work per unit of length." Now let us compare these two definitions of force. It is first, on the authority of Newton emphatically endorsed, said to be that which changes the state of a body. Then it is said to be the rate at which an agent does work (doing work being equivalent to changing a body's state). In the one case, therefore, force itself is the agent which does the work or changes the state; in the other case, force is the rate at which some other agent does the work or changes the state. How are these statements to be reconciled? Otherwise put, the difficulty stands thus: force is that which changes the state of a body; force is a rate, and a rate is a relation (as between time and distance, interest and capital); therefore a relation changes the state of a body. A relation is no longer a *nexus* among phenomena, but becomes a producer of phenomena. Whether Professor Tait succeeded in dispelling "the widespread ignorance as to some of the most important elementary principles of physics," whether his audience went away with clear ideas of the "much-abused and misunderstood term" force, the report does not tell us.

Let us pass now from these illustration of Professor Tait's judgment, as exhibited in his special department, to the consideration of his judgment on a wider question here before us—the formula of evolution. In "Nature," for July 17, 1879, while reviewing Sir Edmund Beckett's "Origin of the Laws of Nature," and praising it, he says of the author: "He follows, in fact, in his own way, the hint given by a great mathematician (Kirkman), who made the following exquisite translation of a well-known definition: 'Evolution is a change from an indefinite, incoherent homogeneity to a definite, coherent heterogeneity, through continuous differentiations and integrations.'* [*Translation into plain English:*] Evolution is a change from a nohowish, untalkaboutable all-alikeness to a somehowish and in-general-talkaboutable not-all alikeness, by continuous somethingelseifications and sticktogetherations."

Professor Tait, proceeding then to quote from Sir Edmund Beckett's book passages in which, as he thinks, there is a kindred tearing off of disguises from the expressions used by other authors, winds up by saying—"When the purposely vague statements of the materialists and agnostics are thus stripped of the tinsel of high-flown and unintelligible language, the eyes of the thoughtless who have accepted them on authority (!) are at last opened, and they are ready to exclaim with Titania, methinks, 'I was enamored of an ass.'" And that Mr. Kirkman similarly believes that his travesty proves the formula of evolution to be meaningless, is shown by the sentence which follows it: "Can any man show that my translation is unfair?"

One would have thought that Mr. Kirkman and Professor Tait, however narrowly they limited themselves to their special lines of inquiry, could hardly have avoided observing that in proportion as scientific terms express wider generalities, they necessarily lose that vividness of suggestion which words of concrete meanings have; and, therefore, to the uninitiated seem vague, or even empty. If Professor Tait enunciated to a rustic the physical axiom, "action and reaction are equal and opposite," the rustic might, not improbably, fail to form any corresponding idea. And he might, if his self-confidence were akin to that of Mr. Kirkman, conclude that where he saw no meaning

* A conscientious critic usually consults the latest edition of the work he criticises, so that the author may have the benefit of any corrections or alterations he has made. Apparently, Mr. Kirkman does not think such a precaution needful. Publishing, in 1876, his "Philosophy without Assumptions," from which the above passage is taken, he quotes from the first edition of "First Principles," published in 1862; though in the edition of 1867, and all subsequent ones, the definition is, in expression, considerably modified—two of the leading words being no longer used.

there could be no meaning. Further, if, after the axiom had been brought partially within his comprehension by an example, he were to laugh at the learned words used and propose to say instead, "shoving and back-shoving are one as strong as the other," it would possibly be held by Professor Tait that this way of putting it is hardly satisfactory. If he thought it worth while to enlighten the rustic, he might, perhaps, point out to him that his statement did not include all the facts—that not only shoving and back-shoving, but also pulling and back-pulling, are one as strong as the other. Supposing the rustic were not too conceited, he might eventually be taught that the abstract, and to him seemingly vague, formula, "action and reaction are equal and opposite," was chosen because by no words of a more specific kind could be expressed the truth in its entirety. Professor Tait, however, and Mr. Kirkman, though the physical and mathematical terms they daily employ are so highly abstract as to prove meaningless to those who are unfamiliar with the concrete facts covered by them, seem not to have drawn any general inference from this habitual experience. For, had they done so, they must have been aware that a formula expressing all orders of changes in their general course—astronomic, geologic, biologic, psychologic, sociologic—could not possibly be framed in any other than words of the highest abstractness. Perhaps there may come the rejoinder that they do not believe any such universal formula is possible. Perhaps they will say that the on-going of things, as shown in our planetary system, has nothing in common with the on-going of things which has brought the earth's crust to its present state, and that this has nothing in common with the on-going of things which the growths and actions of living bodies show us; although, considering that the laws of molar motion and the laws of molecular action are proved to hold true of them all, it requires considerable courage to assert that the modes of coöperation of the physical forces in these several regions of phenomena present no traits in common. But, unless they allege that there is one law for the redistribution of matter and motion in the heavens, and another law for the redistribution of matter and motion in the earth's inorganic masses, and another law for its organic masses—unless they assert that the transformation everywhere in progress follows here one method and there another—they must admit that the proposition which expresses the general course of the transformation can do it only in terms remote in the extremest degree from words suggesting definite objects and actions.

After noting the unconsciousness thus betrayed by Mr. Kirkman and Professor Tait, that the expression of highly abstract truths necessitates highly abstract words, we may go on to note a scarcely less remarkable anomaly of thought shown by them. Mr. Kirkman appears to think, and Professor Tait apparently agrees with him in thinking, that when one of these abstract words, coined from Greek or Latin roots, is transformed into an uncouth-looking combination of equivalents of Saxon, or rather old English origin, what they regard as its misleading glamour is thereby dissipated and its meaninglessness made manifest. We may conveniently observe the nature of Mr. Kirkman's belief by listening to an imaginary addition to that address before the Literary and Philosophical Society of Liverpool in which he first set forth the leading ideas of his volume; and we may fitly, in this imaginary addition, adopt the manner in which he delights:

"Observe, gentlemen," we may suppose him saying, "I have here the yolk of an egg. The evolutionists—using their jargon—say that one of its characters is 'homogeneity'; and, if you do not examine your thoughts, perhaps you may think that the word conveys some idea. But, now if I translate it into plain English, and say that one of the characters of this yolk is 'all-alikeness,' you at once perceive how nonsensical is their statement. You see that the substance of the yolk is not all-alike, and that therefore all-alikeness can not be one of its attributes. Similarly with the other pretentious term, 'heterogeneity,' which, according to them, describes the state things are brought to by what they call evolution. It is mere empty sound, as is manifest if I do but transform it, as I did the other, and say instead 'not-all-alikeness.' For, on showing you this chick, into which the yolk of the egg turns, you will see that 'not-all-alikeness' is a character which can not be claimed for it. How can any one say that the parts of the chick are not-all-alike? Again, in their blatant language we are told that evolution is carried on by continuous 'differentiations'; and they would have us believe that this word expresses some fact. But, if we put instead of it 'somethingelseifications,' the delusion they try to practice on us becomes clear. How can they say that while the parts have been forming themselves the heart has been becoming something else than the stomach, and the leg something else than the wing, and the head something else than the tail? The like manifestly happens when for 'integrations' we read 'sticktogetherations': what sense the term might seem to have becomes obvious nonsense when the substituted word is used. For nobody dares assert that the parts of the chick stick together any more than do the parts of the yolk. I need hardly show you that now when I take a portion of the yolk between my fingers and pull, and now when I take any part of the chick, as the leg, and pull, the first resists just as much as the last, the last does not stick together any more than the first; so that there has been no progress in 'sticktogetherations.' And thus, gentlemen, you perceive that these big words which, to the disgrace of the Royal Society, appear even in papers published by it, are mere empty bladders, which these would-be philosophers use to buoy up their ridiculous doctrines."

There is a further curious mental trait exhibited by Mr. Kirkman, and which Professor Tait appears to have in common with him. Very truly it has been remarked that there is a great difference between disclosing the absurdities contained *in* a thing and piling absurdities *upon* it; and a remark to be added is that some minds appear incapable of distinguishing between intrinsic absurdity and extrinsic absurdity. The case before us illustrates this remark; and at the same time shows us how analytical faculties of one kind may be constantly exercised without strengthening analytical faculties of another kind—how mathematical analysis may be daily practiced without any skill in psychological analysis being acquired. For, if these gentlemen had analyzed their own thoughts to any purpose, they would have known that incongruous juxtapositions may, by association of ideas, suggest characters that do not at all belong to the things juxtaposed. Did Mr. Kirkman ever observe the result of putting a bonnet on a nude statue? If he ever did, and if he then reasoned after the manner exemplified above, he doubtless concluded that the obscene effect belonged intrinsically to the statue, and only required the addition of the bonnet to make it conspicuous. The alternative conclusion, however, which perhaps most will draw, is that not in the statue itself was there anything of an obscene suggestion, but that this effect was purely adventitious: the bonnet, connected in daily experience with living women, calling up the thought of a living woman with the head dressed but otherwise naked. Similarly though, by clothing an idea in words which excite a feeling of the ludicrous by their oddity, any one may associate this feeling of the ludicrous with the idea itself, yet he does not thereby make the idea ludicrous; and, if he thinks he does, he shows that he has not practiced introspection to much purpose.

By way of a lesson in mental discipline, it may be not uninstructive here to note a curious kinship of opinion between these two mathematicians and two *littérateurs*. At first sight it appears strange that men, whose lives are passed in studies so absolutely scientific as those which Professor Tait and Mr. Kirkman pursue, should, in their judgments on the formula of evolution, be at one with two men of exclusively literary culture—a North American Reviewer and Mr. Matthew Arnold. In the "North American Review," vol. cxx., page 202, a critic, after quoting the formula of evolution, says, "This may be all true, but it seems at best rather the blank form for a universe than anything corresponding to the actual world about us." On which the comment may be, that one, who had studied celestial mechanics as much as the critic has studied the general course of transformations, might similarly have remarked that the formula, "bodies attract one another directly as their masses and inversely as the squares of their distances," was at best but a blank form for solar systems and sidereal clusters. With this parenthetical comment, I pass to the fact above hinted, that Mr. Matthew Arnold obviously coincides with the critic's estimate of the formula. In Chapter V. of his work "God and the Bible," when preparing the way for a criticism on German theologians as losing themselves in words, he quotes a saying from Homer. This he introduces by remarking that "it is not at all a grand one. We are almost ashamed to quote it to readers who may have come fresh from the last number of the 'North American Review,' and from the great sentence there quoted as summing up Mr. Herbert Spencer's theory of evolution, 'Evolution is, etc.' Homer's poor little saying comes not in such formidable shape. It is only this : *Wide is the range of words! words may make this way or that way.*" And then he proceeds with his reflections upon German logomachies. All of which makes it manifest that, going out of his way, as he does, to quote this formula from the "North American Review," he intends tacitly to indicate his agreement in the reviewer's estimate of it.

That these two men of letters, like the two mathematicians, are unable to frame ideas answering to the words in which evolution at large is expressed, seems manifest. In all four, the verbal symbols used call up either no images, or images of the vaguest kinds, which, grouped together, form but the most shadowy thoughts. If, now, we ask what is the common trait in the education and pursuits of all four, we see it to be lack of familiarity with those complex processes of change which the concrete sciences bring before us. The men of letters, in their early days dieted on grammars and lexicons, and in their later days occupied with *belles-lettres*, biography, and a history made up mainly of personalities, are by their education and course of life left almost without scientific ideas of a definite kind. The universality of physical causation, the interpretation of all things in terms of a never-ceasing redistribution of matter and motion, is naturally to them an idea utterly alien. The mathematician, too, and the mathematical physicist, occupied exclusively with the phenomena of number, space, and time, or, in dealing with forces, dealing with them in the abstract, carry on their researches in such ways as may, and often do, leave them quite unconscious of the traits exhibited by the general transformations which things, individually and in their totality, undergo. In a chapter on "Discipline," in the "Study of Sociology," I have commented upon the uses of the several groups of sciences—abstract, abstract-concrete, and concrete—in cultivating different powers of mind ; and have argued that while, for complete preparation, the discipline of each group of sciences is indispensable, the discipline of any one group alone, or any two groups, leaves certain defects of judgment. Especially have I contrasted the analytical habit of thought which study of the abstract and abstract-concrete sciences produces with the synthetical habit of thought produced by study of the concrete sciences. And I have exemplified the defects of judgment to which the analytical habit, unqualified by the synthetical habit, leads. Here we meet with a striking illustration. Scientific culture of the analytical kind, almost as much as absence of scientific culture, leaves the mind bare of those ideas with which the concrete sciences deal. Exclusive familiarity with the *forms* and *factors* of phenomena no more fits men for dealing with the *products* in their totalities than does mere literary study.

THE INDIA-RUBBER INDUSTRIES.*

By THOMAS BOLAS, F. C. S.

INDIA-RUBBER, or caoutchouc, possesses properties so widely different from those of most other substances that it became an object of very great interest as soon as it made its appearance in the civilized world, and its industrial importance has rapidly increased as the knowledge of its remarkable characters and manifold applicability has become more extended. At the present time, caoutchouc holds such an important position with regard to the economy of modern arts and manufactures, that, were it suddenly to be withdrawn from circulation, many minor industries would in consequence cease to exist; while numerous large and important branches of handicraft would languish until arrangements could be made to adapt their operations to the altered circumstances.

It is, however, during the last forty years that India-rubber has enjoyed its greatest triumphs as an industrial agent—that is to say, since the art of vulcanization was discovered and perfected by the labors of Charles Goodyear, Thomas Hancock, and others.

The earliest rumor of the existence of caoutchouc reached Europe nearly five hundred years ago; the first visit of Columbus to Hayti having brought to light the fact that the natives of this island were in the habit of making playing-balls of an elastic gum. Nothing more appears to have been heard of India-rubber until Torquemada, rather over two hundred and fifty years ago, described the Mexican Indians as not only making playing-balls of India-rubber, but also as fabricating helmets, shoes, water-proof fabrics, and other articles of elastic gum. This writer gives some details as to the collection of the juice and the making of various articles from it, thus giving us the first view of the India-rubber manufacture as a branch of industry. We do not hear, however, of samples of India-rubber reaching Europe until long after this, and little more appears to have been learned regarding the substance until the celebrated French naturalist, La Condamine, made a communication to the Academy of Sciences at Paris concerning caoutchouc, he having had ample opportunities of studying the subject in Para. In the memoir in question, La Condamine gives very detailed particulars regarding the Para India-rubber tree, the collection and treatment of the juice, and the methods made use of by the natives for the production of various articles of caoutchouc. He tells us that the substance in question was used for making torches, these being only an inch and a half in diameter by two feet long, and yet burning for twelve hours. Again we hear of the use of India-rubber for the making of playing-balls, and it appears that the natives were in the habit of using enema or injection bottles made of caoutchouc.

* Lecture before the London Society of Arts.

Soon after La Condamine's communication to the Academy of Sciences, samples of India-rubber frequently reached Europe, and scientific men began to make investigations regarding this remarkable body. Between 1760 and 1770 we find Fresneau and Macquer studying the subject, and the last-named investigator made tubes and other articles of caoutchouc by dissolving it in ether and coating molds with the solution, so that a solid skin of caoutchouc should remain adherent to the mold on the evaporation of the solvent.

From this time until the end of the eighteenth century, the India-rubber industry may be considered to have been undergoing its period of gestation, and to have been born with the dawn of the present century. Among the first of the important patents regarding the utilization of caoutchouc is that granted in 1823 to Charles Macintosh, for dissolving the substance in coal-oil, or coal-naphtha, and the use of this solution as a water-proofing agent. I have here a specimen of such a solution, as now manufactured by Messrs. Charles Macintosh and Co., of Manchester, together with some examples illustrating its uses.

About the same time, elastic webbing was first made with threads cut from the raw rubber, and other minor applications of caoutchouc to the industrial arts were adopted from time to time, until the great discovery of vulcanization inaugurated a new epoch in this branch of industry, rendering it possible to so far alter caoutchouc as to make it capable of resisting, to a great extent, the action of heat on the one hand and cold on the other hand.

The milky sap of many plants contains caoutchouc, suspended in the form of minute transparent globules, these being frequently as small as $\frac{1}{20000}$ to $\frac{1}{50000}$ of an inch in diameter; but comparatively few plants contain sufficient caoutchouc to render them important sources of this body.

The trees which yield the largest supply of the best quality of caoutchouc consist of various species of hevea, which flourish in the northern districts of South America, especially in the province of Para, some portions of the valley of the Amazon being crowded to an extraordinary extent with heveas. The abundance of the India-rubber trees in Para may be judged of by the fact that this province alone exported 7,340 tons of caoutchouc in the year 1877, more than half of this being sent to Liverpool.

Among the heveas most productive of caoutchouc may be mentioned the *Hevea Brasiliensis*, which flourishes in Para, and yields some of the finest caoutchouc, and often attains a height of sixty to seventy feet, with a diameter of nearly three feet; the *Hevea Guianensis*, a similarly magnificent tree, likewise abundantly productive of caoutchouc; and the *Hevea spruceana*, a smaller tree, which grows almost exclusively in the province of Para. Fig. 1 represents the flowers and foliage of *Hevea Guianensis.*

In the operation of collecting the juice several cuts are made through the bark of the tree, and either shells or clay vessels are attached to receive the exuding milky sap. When sufficient of this has been collected, the operation of drying it is performed as follows: A kind of

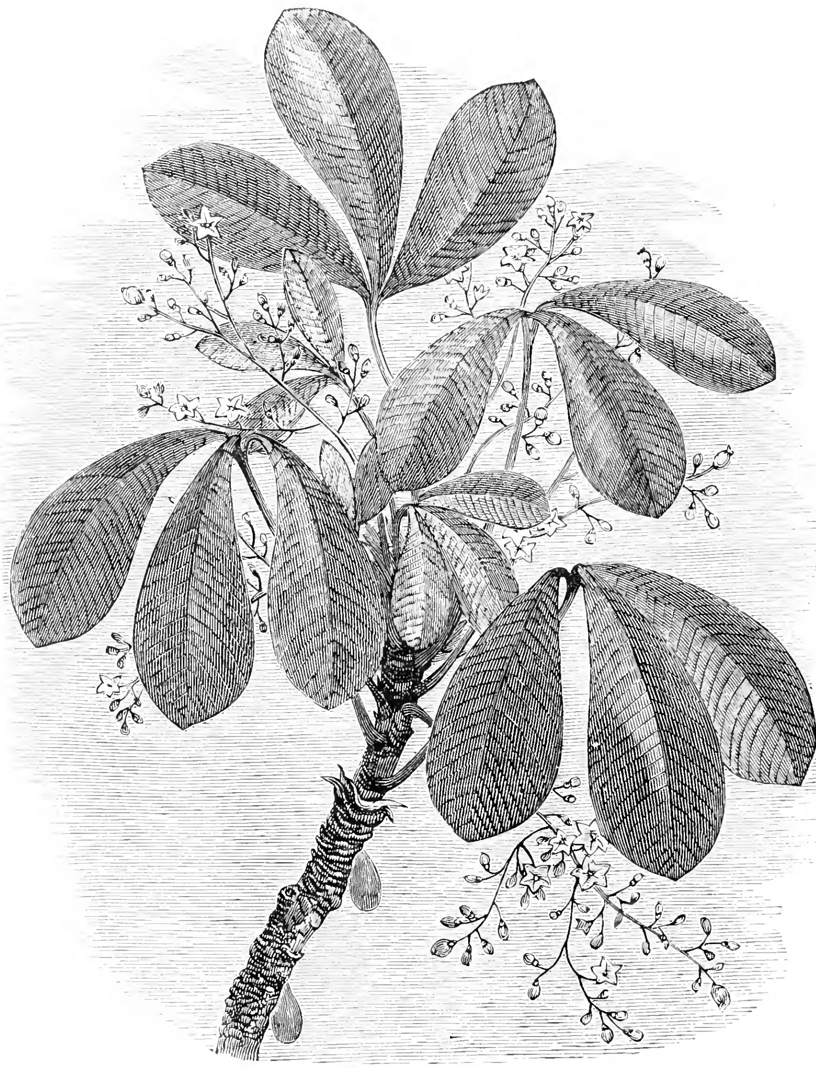


Fig. 1.—Hevea Guianensis (Flower and Foliage).

wooden bat, thinly covered over with clay, is dipped into a pail filled with the juice, and the bat, thus coated, is held over a fire, fed with certain wild nuts, which, in burning, give off abundance of aromatic smoke. Fig. 2 represents this operation, and you will see that a kind of short chimney is fixed over the fire to lead the smoke compactly upward. As soon as the first layer of juice has become indurated, the bat is again dipped, and the drying operation is repeated, layer after layer being thus dried on the bat, until a thickness of nearly an inch is attained. A knife-cut is now made in the bottle or biscuit of caoutchouc thus obtained, so that it can be removed from the wooden bat, and exposed to the air to become still further indurated. Para caoutchouc, prepared in this manner, has a fragrant, aromatic odor, which you can study for yourselves in the samples now before you.

The residues of juice left in the various vessels employed, the scrapings of the incisions, together with other materials, which the ingenious native thinks he can shuffle off on the unsuspecting merchant as caoutchouc, are made into balls, and sold as "negro-head." The negro-head rubber is frequently made into crude representations of animals, and there are several such works of native art on the table—as, for example, this specimen, which will pass about equally well for a horse, a pig, or a crocodile.

Here is a piece of Para bottle-rubber, which has been boiled for some hours in water, and you see that it is now so far softened as to render it easy to pull asunder the several layers of which it is composed, its laminated structure being thus very well illustrated.

The milky juice of the Para rubber trees, of which you see a specimen before you, has approximately the following composition :

Caoutchouc	32
Albuminous, extractive, and saline matters	12
Water	56
Total	100

As a rubber-producing tree, the *Ficus elastica* stands next in importance of the heveas. The *Ficus elastica* grows abundantly in India and the East Indian Islands, one district in Assam, thirty miles long by eight miles wide, being said to contain 43,000 trees, many of them attaining a height of a hundred feet. This tree also grows freely in Madagascar, and it is well known to us as a greenhouse plant. Fig. 3 represents a *Ficus elastica* now growing out of doors in the Parc Monceau at Paris.

The juice of the *Ficus elastica* contains notably less caoutchouc than that of the American trees, the proportion very often falling as low as ten per cent. of the juice.

A vine-like plant, the *Urceola elastica*, which grows abundantly in Madagascar, Borneo, Singapore, Sumatra, Penang, and other places, yields a considerable amount of caoutchouc of very good quality. Africa yields a considerable quantity of caoutchouc, but generally soft and of inferior quality. It is believed to be yielded by various species of landolphia, ficus, and toxicophlea. Here are some specimens of African rubber—this specimen, representing the quality known as

African ball, being tolerably firm in consistency, while the African flake, which you see here, and the African tongue, represent the lowest and most viscous qualities of commercial rubber.

The commercial value of the various qualities of rubber may be estimated, to a certain extent, by noting the loss which the samples undergo during the operation of washing, and also by noticing how far the various samples are softened by a long-continued gentle heat. Here are some samples which have been heated for some hours in this water-oven; you will notice that the African tongue has become almost as soft as treacle, while the Para rubber still retains its form and much of its consistency.

Caoutchouc is nearly colorless, and when in thin leaves tolerably transparent. It, like very many other substances, contains nothing but carbon and hydrogen, but its properties differ very widely from those of other hydrocarbons almost identical in composition. It has been found to contain, in one hundred parts, 12·5 of hydrogen and 87·5 of carbon. Caoutchouc, as might be supposed, burns very readily and leaves no residue; if I set fire to a few ounces, you see how it blazes up. It is soft, and very imperfectly elastic, in the true sense of the term—that is to say, it does not return to its old dimensions after having been considerably stretched. Here is a strip of pure (i. e., unvulcanized) caoutchouc a foot long; you see that I have stretched it to a length of three feet, and, after holding it stretched for a few seconds, I relax it. It now measures, as you see, several inches over the foot. The elasticity of caoutchouc may be enormously increased by vulcanization.

As regards the stretching of India-rubber, there is a point at which it requires a greatly increased force to stretch it, and at this point it seems to become fibrous in texture, as you may perceive by examining this extended sample by the aid of a magnifying-lens. India-rubber has valuable electrical properties, as you are no doubt aware, it being an admirable insulator, and having a great tendency to become electrical by friction.

Freshly cut surfaces of India-rubber cohere very strongly when brought into contact, and this is well illustrated by the old way of making a tube of unvulcanized caoutchouc. You see that I wrap a sheet of caoutchouc round a mandrel, so that the edges project parallel to each other. These parallel edges being cut off by means of scissors, the freshly cut edges adhere, and a perfect tube is the result. Toy balloons are made in a somewhat analogous manner, and are cold vulcanized afterward.

Either French chalk or soapy water is of constant use in the rubber-factories, to prevent the adhesion of new surfaces of caoutchouc to each other, or to other substances.

Cold has a remarkable effect on caoutchouc, rendering it rigid and inelastic, and this circumstance considerably detracts from the value of unvulcanized India-rubber. Here is a strip of India-rubber; you see that it is quite soft and pliable. I will now expose it for a few minutes to a temperature of 0° Centigrade, or the freezing-point of

FIG. 2.—THE OPERATION OF DRYING THE INDIA-RUBBER JUICE.

water. It becomes, as you see, rigid and stiff, but its original pliability may be restored, either by warming, or by applying sufficient tensile strain to it, to extend it to three or four times its length. One half of this strip I will warm in water, heated to 50° Cent., and the other I will stretch. In each case you see that the caoutchouc is restored to its original condition. In the case of the stretching it is very likely that the effect is due to the heat evolved during that operation. It is easy to illustrate the fact that heat is produced when India-rubber is subjected to tension. Here are some strips of India-rubber, arranged side by side on a board. I bring them in contact with the bulb of an air-thermometer, and you see that there is no indication of either heat or cold. The strips of India-rubber being now stretched to four or five times their previous length, the air-thermometer indicates a considerable rise of temperature. Here is a similar set of strips, which were stretched some hours ago, and which on trial by the air-thermometer we now find to have cooled down to the temperature of the surrounding objects. Note the effect of releasing the tension and allowing the rubber strips to contract. You see that they have become so cold as to influence the air-thermometer to a very considerable extent.

The effects of heat on India-rubber present many points of interest, and, in the first place, I wish to illustrate to you the effect of moderate heat on a stretched band of caoutchouc. Here is such a band, one end being attached to an index, pointing, at the present time, to the zero of this paper scale. Notice the consequence of applying a gentle heat to the caoutchouc band—it contracts as regards its length, but expands in a transverse direction, causing the index to move rapidly through a space of several degrees. This property, which stretched caoutchouc possesses, of contracting by heat, may be described by saying that, within certain limits, the tensile elasticity of caoutchouc is increased by an elevation of temperature. Caoutchouc, however, if heated to 100° Cent., softens considerably, and almost entirely loses its elasticity, as you will perceive by examining this sample, which has been heated for some hours; while a heat of 120° Cent. produces a most decided softening effect on caoutchouc of the best quality, but after exposure to this temperature, it recovers its pristine state by exposure to cold for a moderate period. If, however, the action of heat has been pushed still further, say to 200 Cent., the caoutchouc becomes converted into a permanently viscous body, which has little or no tendency to harden again. This viscous substance possesses the same composition as unaltered caoutchouc, and is of value as a medium for making air-tight joints, which can be easily undone. This glass jar has its top edge ground level, and, after applying a little of the heated caoutchouc to the ground edge, the jar may, as you see, be hermetically closed by a disk of plate-glass. A joint of this kind may be broken and remade with the utmost facility and rapidity.

When caoutchouc is subjected to a temperature somewhat above 200 Cent., it becomes converted into a variety of volatile hydrocarbons, which present many points of interest, and you will find a tolerably full account of them in the manuals of chemistry. In this retort, the dry distillation of caoutchouc is being carried on, and in time very nearly the whole of the India-rubber will be converted into the mixture of oily hydrocarbons, only an insignificant carbonaceous residue remaining in the retort. The mixture of volatile hydrocarbons, often referred to as caoutchoucine, forms a very good solvent for caoutchouc and certain resinous bodies.

India-rubber is subject to two kinds of deterioration and decay. In one instance it tends to become soft, and loses its elasticity, while in the other it becomes friable, yellowish, and resinous in its nature. Examples of each kind of deteriorated rubber are on the table, and you will notice that, in the case of this specimen, we have a well-marked instance of both kinds of deterioration going on side by side. The last-mentioned kind of deterioration has been clearly and indubitably traced to an oxidation of the caoutchouc. This oxidation is tolerably rapid when the caoutchouc exists in a finely divided state, and when it is exposed to damp at the same time; but the alternate damping and drying of the caoutchouc tends more toward its rapid oxidation than does a continual state of dampness. The resinous matter resulting from the oxidation of caoutchouc has been carefully studied by Spiller, who found that a sample of felt, originally composed of cotton fibers and India-rubber, had become so far changed during six years as to contain no trace of caoutchouc; but in its place he found a resinous substance resembling shellac. This resinous body, of which a sample is before you is easily soluble in alcohol, and also dissolves in benzole. Alkalies dissolve it readily, and acids precipitate it from the alkaline solution. It contains 27·3 per cent. of oxygen.

The conditions under which the softening of the India-rubber takes place are not so well understood, but there is some reason to believe that this is due to incipient oxidation.

Ozone oxidizes caoutchouc with extreme rapidity, as Warren pointed out in 1877, and I have arranged a simple experiment to illustrate this fact. Through the open end of this glass passes a slow stream of air which has been slightly ozonized; that is to say, a portion of its oxygen has been converted into ozone. When the stream of ozonized air is allowed to impinge on a surface of India-rubber, you see that the surface is instantly corroded and roughened. Again, note the effect of allowing the ozonized air to act on the surface of a distended caoutchouc balloon—you see that it bursts immediately. I should mention, by the by, that in the case of these balloons the caoutchouc is slightly vulcanized, but the action of ozone on vulcanized India-rubber is similar to its action on the unvulcanized material.

It is extremely probable that the rapid deterioration of caoutchouc, which is known to take place under conditions which are not perfectly understood, is frequently due to the corrosive and oxidizing action of ozone.

Ozone, or some agent nearly resembling it, is often produced when oil of turpentine is exposed to the air, and this circumstance may per-

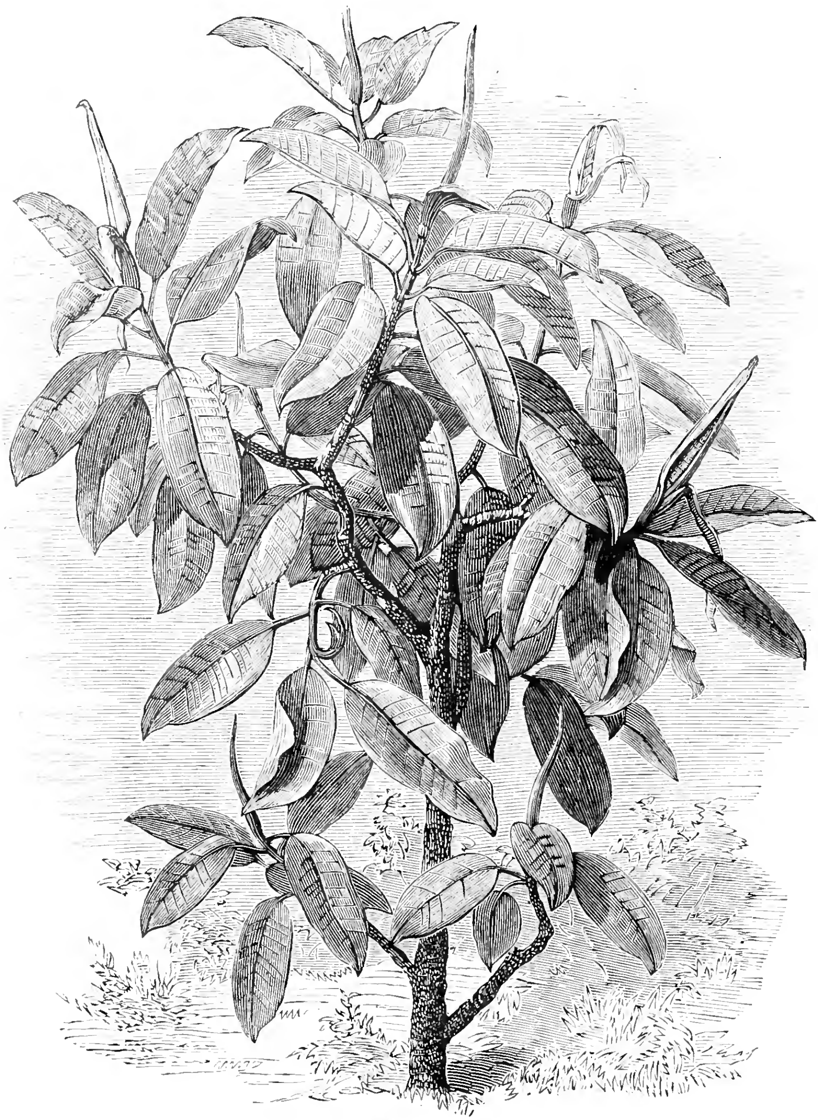


Fig. 3.—Ficus Elastica; a Specimen growing in the Open Air at Paris.

haps explain the destructive influence which oil of turpentine occasionally exercises on India-rubber.

Exposure to sunlight often causes the destruction of India-rubber, either converting it into a soft and sticky substance, or into a hard body, less soluble in benzole than unaltered caoutchouc ; and it is quite possible to obtain a photographic print by exposing a film of India-rubber under a negative, and then dissolving away, by means of benzole, those parts on which the light has not acted. Here is such a photograph made by Mr. Woodbury. I now project it on the screen, so that you may all see it. It is generally a discreet thing to keep India-rubber where it will not be exposed to the prolonged action of a powerful light, although there are cases in which exposure to light is a useful aid to the process of vulcanization. India-rubber is, to a certain extent, porous and cellular in its texture, as may be seen by a microscopical examination of a thin section. Again, if a thin leaf of caoutchouc is boiled for a long time in water, it absorbs a considerable proportion of this liquid. You see that this piece of caoutchouc has become quite milky and translucent from the absorption of water, and it probably holds, at the present time, as much as ten or fifteen per cent. of water. The amount absorbed may, in some cases, rise as high as twenty-five per cent. In a similar manner alcohol is absorbed by India-rubber, more readily than is the case with water.

Now, we pass on to a more important matter, namely, the action of such liquids as benzole or coal-naphtha on caoutchouc. Here are two cubes of Para rubber, each being three eighths of an inch across the face. One of these I will preserve as a pattern, and the other I will suspend in a bottle containing benzole. The cube suspended in the benzole will immediately begin to swell, and will continue to do so until it has attained a bulk about one hundred times as large as its original size. During the time that the cube is swelling in the benzole, a certain proportion of the caoutchouc will become dissolved out and incorporate itself with the bulk of the solvent. Now, as a matter of fact, every kind of natural India-rubber contains two distinct modifications of caoutchouc, one of which tends to swell up in such a liquid as benzole, while the other dissolves and forms a true solution. The first mentioned of these bodies may be referred to as the fibrous constituent of caoutchouc, while the second may be spoken of as the viscous constituent. The proportions in which these two bodies occur in raw rubber vary extremely, Para rubber, of good quality, containing only a small proportion of the viscous constituent, while African tongue, on the other hand, consists principally of the viscous modification of caoutchouc. The viscous constituent of caoutchouc is the agent principally concerned in the joining together of freshly cut edges of India-rubber ; and, as we proceed with the study of caoutchouc, we shall see that, under certain conditions, the fibrous caoutchouc can be more or less perfectly changed into the viscous form. The treatment of the juice of the India-rubber trees is often of such a nature as to greatly deteriorate the caoutchouc obtained ; a considerable proportion being thus changed from the fibrous to the viscous condition. This kind of injury to the caoutchouc can be obviated by coagulating the milky juice, and carefully drying the clot after it has been subjected to pressure. For experimental purposes, alcohol may be employed as a coagulating agent; while, on an industrial scale, alum has been tried with apparently an excellent result. The milk is strained to remove solid impurities, after which a small proportion of alum solution is added. The clot which separates is next drained or pressed, after which it is dried. Caoutchouc dissolves more or less perfectly, according to its condition in various liquids, among which may be mentioned

Fig. 4.—Cube of Para Caoutchouc unswelled.

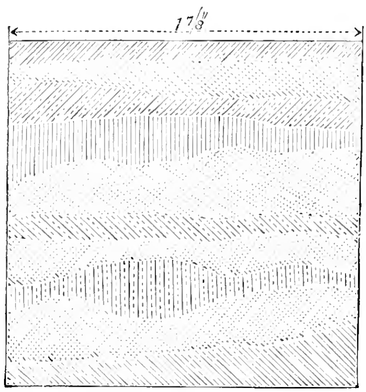


Fig. 5.—Similar Cube swelled by the Prolonged Action of Benzole.

the various fixed and hydrocarbon oils, chloroform, ether, and carbon disulphide. Unless, however, the caoutchouc has been masticated or otherwise degenerated, it is doubtful whether a true solution is obtained. When a clear limpid solution is required, one of the best solvents is that proposed by Payen, namely, carbon disulphide, mixed with five per cent. of absolute alcohol. If one part of masticated caoutchouc is dissolved in thirty parts of the above solvent, a solution is obtained which can be filtered through paper, and may be employed in covering the most delicate molds with successive layers of caoutchouc.

Caoutchouc may be utterly ruined by the use of impure solvents, and those experimenting with India-rubber solutions should, in cases where it is desirable to regenerate the caoutchouc by allowing the solvent to evaporate, take the utmost care not to employ any solvents which contain fatty or greasy matter.

Weak or diluted acids have little or no action on caoutchouc in the majority of cases, but strong sulphuric acid slowly acts on it, the action becoming rapid if heat be applied. Strong nitric acid acts on it with some energy, causing its entire destruction, and in a similar manner it is destroyed by the prolonged action of chlorine, bromine, or iodine; although these reagents, when their action is kept under control, produce a vulcanizing or strengthening effect.—*Abridged from Journal of the Society of Arts.*

ON THE PRODUCTION OF SOUND BY LIGHT.*

By ALEXANDER GRAHAM BELL.

IN bringing before you some discoveries made by Mr. Sumner Tainter and myself, which, having resulted in the construction of apparatus for the production and reproduction of sound by means of light, it is necessary to explain the state of knowledge which formed the starting-point of our experiments. I shall first describe the remarkable substance selenium, and the manipulations devised by various experimenters; but the final result of our researches has extended the class of substances sensitive to light-vibrations, until we can propound the fact of such sensitiveness being a general property of all matter. We have found this property in gold, silver, platinum, iron, steel, brass, copper, zinc, lead, antimony, German silver, Jenkin's metal, Babbitt's metal, ivory, celluloid, gutta-percha, hard rubber, soft vulcanized rubber, paper, parchment, wood, mica, and silvered glass; and the only substances from which we have not obtained results are carbon and thin microscopic glass. We find that when a vibratory beam of light falls upon these substances they emit sounds, the pitch of which depends upon the frequency of the vibratory change in the light. We find, further, that, when we control the form or character of the light-vibration on selenium, and probably on the other substances, we control the quality of the sound and obtain all varieties of articulate speech. We can thus, without a conducting wire, as in electric telephony, speak from station to station, wherever we can project a beam of light. We have not had opportunity of testing the limit to which this photophonic influence can be extended, but we have spoken to and from points two hundred and thirteen metres apart; and there seems no reason to doubt that the results will be obtained at whatever distance a beam of light can be flashed from one observatory to another. The necessary privacy of our experiments hitherto has alone prevented any attempts at determining the extreme distance at which this new method of vocal communication will be available. I shall now speak of selenium.

* Lecture delivered before the American Association for the Advancement of Science, in the Institute of Technology, Boston, August 27, 1880.

In the year 1817 Berzelius and Gottlieb Gahn made an examination of the method of preparing sulphuric acid in use at Gripsholm. During the course of this examination, they observed in the acid a sediment of a partly reddish, partly clear brown color, which, under the action of the blowpipe, gave out a peculiar odor, like that attributed by Klaproth to tellurium. As tellurium was a substance of extreme rarity, Berzelius attempted its production from this deposit; but he was unable, after many experiments, to obtain further indications of its presence. He found plentiful signs of sulphur mixed with mercury, copper, zinc, iron, arsenic, and lead, but no trace of tellurium. It was not in the nature of Berzelius to be disheartened by this result. In science every failure advances the boundary of knowledge as well as every success, and Berzelius felt that, if the characteristic odor that had been observed did not proceed from tellurium, it might possibly indicate the presence of some substance then unknown to the chemist. Urged on by this hope he returned with renewed ardor to his work. He collected a great quantity of the material, and submitted the whole mass to various chemical processes. He succeeded in separating successively the sulphur, the mercury, the copper, the tin, and the other known substances whose presence had been indicated by his tests—and, after all these had been eliminated, there still remained a residue which proved upon examination to be what he had been in search of—a new elementary substance. The chemical properties of this new element were found to resemble those of tellurium in so remarkable a degree that Berzelius gave to the substance the name of "selenium," from the Greek word *selene*, the moon ("tellurium," as is well known, being derived from *tellus*, the earth).

Although tellurium and selenium are alike in many respects, they differ in their electrical properties, tellurium being a good conductor of electricity, and selenium, as Berzelius showed, a non-conductor. Knox discovered in 1837 that selenium became a conductor when fused; and Hittorff in 1852 showed that it conducted at ordinary temperatures, when in one of its allotropic forms. When selenium is rapidly cooled from a fused condition, it is a non-conductor. In this its vitreous form it is of a dark-brown color, almost black by reflected light, having an exceedingly brilliant surface. In thin films it is transparent, and appears of a beautiful ruby red by transmitted light. When selenium is cooled from a fused condition with extreme slowness, it presents an entirely different appearance, being of a dull lead-color, and having throughout a granulated or crystalline structure, and looking like a metal. In this form it is perfectly opáque to light even in very thin films. This variety of selenium has long been known as "granular" or "crystalline" selenium, or, as Regnault called it, "metallic" selenium. It was selenium of this kind that Hittorff found to be a conductor of electricity at ordinary temperatures. He also found that its resistance to the passage of an electrical current diminished continuously by heating up to the point of fusion, and that the resistance suddenly increased in passing from the solid to the liquid condition. It was early discovered that exposure to sunlight hastens the change of selenium from one allotropic form to another; and this observation is significant in the light of recent discoveries.

Although selenium has been known for the last sixty years it has not yet been utilized to any extent in the arts, and it is still considered simply as a chemical curiosity. It is usually supplied in the form of cylindrical bars. These bars are sometimes found to be in the metallic condition; but more usually they are in the vitreous or non-conducting form. It occurred to Willoughby Smith that, on account of the high resistance of crystalline selenium, it might be usefully employed at the shore-end of a submarine cable, in his system of testing and signaling during the process of submersion. Upon experiment, the selenium was found to have all the resistance required—some of the bars employed measuring as much as fourteen hundred megohms—a resistance equivalent to that which would be offered by a telegraph-wire long enough to reach from the earth to the sun! But the resistance was found to be extremely variable. Experiments were made to ascertain the cause of this variability. Mr. May, Mr. Willoughby Smith's assistant, discovered that the resistance was less when the selenium was exposed to light than when it was in the dark.

In order to be certain that temperature had nothing to do with the effect, the selenium was placed in a vessel of water, so that the light had to pass through from one to two inches of water in order to reach the selenium. The approach of a lighted candle was found to be sufficient to cause a marked deflection of the needle of the galvanometer connected with the selenium, and the lighting of a piece of magnesium wire caused the selenium to measure less than half the resistance it did the moment before.

These results were naturally at first received by scientific men with some incredulity, but they were verified by Sale, Draper, Moss, and others. When selenium is exposed to the action of the solar spectrum, the maximum effect is produced, according to Sale, just outside the red end of the spectrum, in a point nearly coincident with the maximum of the heat-rays; but, according to Adams, the maximum effect is produced in the greenish-yellow or most luminous part of the spectrum. Lord Rosse exposed selenium to the action of non-luminous radiations from hot bodies, but could produce no effect; whereas a thermopile under similar circumstances gave abundant indications of a current. He also cut off the heat-rays from luminous bodies by the interposition of liquid solutions, such as alum, between the selenium and the source of light, without affecting the power of the light to reduce the resistance of the selenium; whereas the interposition of these same substances almost completely neutralized the effect upon the thermopile. Adams found that selenium was sensitive to the cold light of the moon, and Werner Siemens discovered that, in certain extremely sensitive varieties of selenium, heat and light produced opposite effects. In Siemens's experiments special arrangements were made for the purpose of reducing the resistance of the selenium employed. Two fine platinum wires were coiled together in the shape of a double flat spiral in the zigzag shape, and were laid upon a plate of mica so that the disks did not touch one another. A drop of melted selenium was then placed upon the platinum-wire arrangement, and a second sheet of mica was pressed upon the selenium, so as to cause it to spread out and fill the spaces between the wires. Each cell was about the size of a silver dime. The selenium-cells were then placed in a paraffine bath, and exposed for some hours to a temperature of 210° Cent., after which they were allowed to cool with extreme slowness. The results obtained with these cells were very extraordinary; in some cases the resistance of the cells when exposed to light was only one fifteenth of their resistance in the dark.

Without dwelling further upon the researches of others, I may say that the chief information concerning the effect of light upon the conductivity of selenium will be found under the names of Willoughby Smith, Lieutenant Sale, Draper and Moss, Professor W. G. Adams, Lord Rosse, Day, Sabini, Dr. Werner Siemens, and Dr. C. W. Siemens. All observations by these various authors had been made by means of galvanometers; but it occurred to me that the telephone, from its extreme sensitiveness to electrical influences, might be substituted with advantage. Upon consideration of the subject, however, I saw that the experiments could not be conducted in the ordinary way, for the following reason: The law of audibility of the telephone is precisely analogous to the law of electric induction. No effect is produced during the passage of a continuous and steady current. It is only at the moment of change from a stronger to a weaker state, or *vice versa*, that any audible effect is produced, and the amount of effect is exactly proportional to the amount of variation in the current. It was, therefore, evident that the telephone could only respond to the effect produced in selenium at the moment of change from light to darkness, or *vice versa*; and that it would be advisable to intermit the light with great rapidity, so as to produce a succession of changes in the conductivity of the selenium, corresponding in frequency to musical vibrations within the limits of the sense of hearing. For I had often noticed that currents of electricity, so feeble as to produce scarcely any audible effects from a telephone when the circuit was simply opened or closed, caused very perceptible musical sounds when the circuit was rapidly interrupted, and that the higher the pitch of sound the more audible was the effect. I was much struck by the idea of producing sound by the action of light in this way. Upon further consideration it appeared to me that all the audible effects obtained from varieties of electricity could also be produced by variations of light acting upon selenium. I saw that the effect could be produced at the extreme distance at which selenium would respond to the action of a luminous body, but that this distance could be indefinitely increased by the use of a parallel beam of light, so that we could telephone from one place to another without the necessity of a conducting wire between the transmitter and receiver. It was evidently necessary, in order to reduce this idea to practice, to devise an apparatus to be operated by the voice of a speaker, by which variations could be produced in a parallel beam of light, corresponding to the variations in the air produced by the voice.

I proposed to pass light through a large number of small orifices, which might be of any convenient shape, but were preferably in the form of slits. Two similarly perforated plates were to be employed. One was to be fixed and the other attached to the center of a diaphragm actuated by the voice, so that the vibration of the diaphragm would cause the movable plate to slide to and fro over the surface of the fixed plate, thus alternately enlarging and contracting the free orifices for the passage of light. In this way the voice of a speaker could control the amount of light passed through the perforated plates without completely obstructing its passage. This apparatus was to be placed in the path of a parallel beam of light, and the undulatory beam emerging from the apparatus could be received at some distant place upon a lens, or other apparatus, by means of which it could be condensed upon a sensitive piece of selenium placed in a local circuit with a telephone and galvanic battery. The variations in the light produced by the voice of the speaker should cause corresponding variations in the electrical resistance of the selenium employed : and the telephone in circuit with it should reproduce audibly the tones and articulations of the speaker's voice. I obtained some selenium for the purpose of producing the apparatus shown ; but found that its resistance was almost infinitely greater than that of any telephone that had been constructed, and I was unable to obtain any audible effects by the action of light. I believed, however, that the obstacle could be overcome by devising mechanical arrangements for reducing the resistance of the selenium, and by constructing special telephones for the purpose. I felt so much confidence in this that, in a lecture delivered before the Royal Institute of Great Britain, upon the 17th of May, 1878, I announced the possibility of hearing a shadow by interrupting the action of light upon selenium. A few days afterward my ideas upon this subject received a fresh impetus by the announcement made by Mr. Willoughby Smith before the Society of Telegraph Engineers that he had heard the action of a ray of light falling upon a bar of crystalline selenium, by listening to a telephone in circuit with it.

It is not unlikely that the publicity given to the speaking telephone during the last few years may have suggested to many minds in different parts of the world somewhat similar ideas to my own.

Although the idea of producing and reproducing sound by the action of light, as described above, was an entirely original and independent conception of my own, I recognize the fact that the knowledge necessary for its conception has been disseminated throughout the civilized world, and that the idea may therefore have occurred to many other minds. *The fundamental idea, on which rests the possibility of producing speech by the action of light, is the conception of what may be termed an undulatory beam of light in contradistinction to a merely intermittent one.* By an undulatory beam of light, I mean a beam that shines continuously upon the selenium receiver, but the intensity of which upon that receiver is subject to rapid changes, corresponding to the changes in the vibratory movement of a particle of air during the transmission of a sound of definite quality through the atmosphere. The curve that would graphically represent the changes of light would be similar in shape to that representing the movement of the air. I do not know whether this conception had been clearly realized by "J. F. W.," of Kew, or by Mr. Sargent, of Philadelphia; but to Mr. David Brown, of London, is undoubtedly due the honor of having distinctly and independently formulated the conception, and of having devised apparatus—though of a crude nature—for carrying it into execution. It is greatly due to the genius and perseverance of my friend Mr. Sumner Tainter, of Watertown, Massachusetts, that the problem of producing and reproducing sound by the agency of light has at last been successfully solved.

The first point to which we devoted our attention was the reduction of the resistance of crystalline selenium within manageable limits. The resistance of selenium-cells employed by former experimenters was measured in millions of ohms, and we do not know of any record of a selenium-cell measuring less than 250,000 ohms in the dark. *We have succeeded in producing sensitive selenium-cells measuring only* 300 *ohms in the dark, and* 155 *ohms in the light.* All former experimenters seemed to have used platinum for the conducting part of their selenium-cells, excepting Werner Siemens, who found that iron and copper might be employed. We have also discovered that brass, although chemically acted upon by selenium, forms an excellent and convenient material; indeed, we are inclined to believe that the chemical action between the brass and selenium has contributed to the low resistance of our cells by forming an intimate bond of union between the selenium and brass. We have observed that melted selenium behaves to the other substances as water to a greasy surface, and we are inclined to think that, when selenium is used in connection with metals not chemically acted upon by it, the points of contact between selenium and the metal offer a considerable amount of resistance to the passage of a galvanic current. By using brass we have been enabled to construct a large number of selenium-cells of different forms. The mode of applying the selenium is as follows: The cell is heated, and, when hot enough, a stick of selenium is rubbed over the surface. In order to acquire conductivity and sensitiveness, the selenium must next undergo a process of annealing.

We simply heat the selenium over a gas-stove and observe its appearance. When the selenium attains a certain temperature, the beautiful reflecting surface becomes dimmed. A cloudiness gradually extends over it, somewhat like the film of moisture produced by breathing upon a mirror. This appearance gradually increases, and the whole surface is soon seen to be in the metallic, granular, or crystalline condition. The cell may then be taken off the stove, and cooled in any suitable way. When the heating process is carried too far, the crystalline selenium is seen to melt. Our best results have been obtained by heating the selenium until it crystallizes, and continuing the heating until signs of melting appear, when the gas is immediately put out. The portions that had melted instantly recrystallize, and the selenium is found upon cooling to be a conductor, and to be sensitive to light. The whole operation occupies only a few minutes. This method has not only the advantage of being expeditious, but it proves that many of the accepted theories on this subject are fallacious. Our new method shows that fusion is unnecessary, that conductivity and sensitiveness can be produced without long heating and slow cooling; and that crystallization takes place during the heating process. We have found that, on removing the source of heat immediately on the appearance of the cloudiness, distinct and separate crystals can be observed under the microscope, which appear like leaden snow-flakes on a ground of ruby red. Upon removing the heat, when crystallization is further advanced, we perceive under the microscope masses of these crystals arranged like basaltic columns standing detached from one another, and at a still higher point of heating the distinct columns are no longer traceable, but the whole mass resembles metallic pudding-stone, with here and there a separate snow-flake, like a fossil, on the surface. Selenium crystals formed during slow cooling after fusion present an entirely different appearance, showing distinct facets.

We have devised about fifty forms of apparatus for varying a beam of light in the manner required, but only a few typical varieties need be shown. The source of light may be controlled, or a steady beam may be modified at any point in its path. The beam may be controlled in many ways. For instance, it may be polarized, and then affected by electrical or magnetic influences in the manner discovered by Faraday and Dr. Ker. The beam of polarized light, instead of being passed through a liquid, may be reflected from the polished pole of an electro-magnet. Another method of affecting a beam of light is to pass it through a lens of variable focus. I observe that a lens of this kind has been invented in France by Dr. Cusco, and is fully described in a recent paper in "La Nature"; but Mr. Tainter and I have used such a lens in our experiments for months past. The best and simplest form of apparatus for producing the effect remains to be described. This consists of a plane mirror of flexible material—such as silvered mica or microscope glass. Against the back of this mirror the speaker's voice is directed. The light reflected from this mirror is thus thrown into vibrations corresponding to those of the diaphragm itself.

In arranging the apparatus for the purpose of reproducing sound at a distance, any powerful source of light may be used, but we have experimented chiefly with sunlight. For this purpose a large beam is concentrated by means of a lens upon the diaphragm-mirror, and, after reflection, is again rendered parallel by means of another lens. The beam is received at a distant station upon a parabolic reflector, in the focus of which is placed a sensitive selenium-cell, connected in a local circuit with a battery and telephone. A large number of trials of this apparatus have been made with the transmitting and receiving instruments so far apart that sounds could not be heard directly through the air. In illustration, I shall describe one of the most recent of these experiments. Mr. Tainter operated the transmitting instrument, which was placed on the top of the Franklin schoolhouse in Washington, and the sensitive receiver was arranged in one of the windows of my laboratory, 1325 L Street, at a distance of two hundred and thirteen metres. Upon placing the telephone to my ear I heard distinctly from the illuminated receiver the words, "Mr. Bell, if you hear what I say, come to the window and wave your hat." In laboratory experiments the transmitting and receiving instruments are necessarily within ear-shot of one another, and we have, therefore, been accustomed to prolong the electric circuit connected with the selenium receiver, so as to place the telephones in another room. By such experiments we have found that articulate speech can be reproduced by the oxyhydrogen light, and even by the light of a kerosene-lamp. The loudest effects obtained from light are produced by rapidly interrupting the beam by the perforated disk. The great advantage of this form of apparatus for experimental work is the noiselessness of its rotation, admitting the close approach of the receiver without interfering with the audibility of the effect heard from the latter; for it will be understood that musical tones are emitted from the receiver when no sound is made at the transmitter. A silent motion thus produces a sound. In this way musical tones have been heard even from the light of a candle. When distant effects are sought another apparatus is used. By placing an opaque screen near the rotating disk the beam can be entirely cut off by a slight motion of the hand, and musical signals, like the dots and dashes of the Morse telegraph code, can thus be produced at the distant receiving station.

We have made experiments with the object of ascertaining the nature of the rays that affect selenium. For this purpose we have placed in the path of an intermittent beam various absorbing substances. Professor Cross has been kind enough to give me his assistance in conducting these experiments. When a solution of alum, or bisulphide of carbon, is employed, the loudness of the sound produced by the intermittent beam is very slightly diminished; but a solution of iodine in bisulphide of carbon cuts off most, but not all, of the audible effect. Even an apparently opaque sheet of hard rubber does not entirely do this. When the sheet of hard rubber was held near the disk interrupter, the rotation of the disk interrupted what was then an invisible beam, which passed over a space of about twelve feet before it reached the lens, which finally concentrated it upon the selenium-cell. A faint but perfectly perceptible musical tone was heard from the telephone connected with the selenium. This could be interrupted at will by placing the hand in the path of the invisible beam. It would be premature, without further experiments, to speculate too much concerning the nature of these invisible rays; but it is difficult to believe that they can be heat-rays, as the effect is produced through two sheets of hard rubber, containing between them a saturated solution of alum. Although effects are produced, as above shown, by forms of radiant energy which are invisible, we have named the apparatus for the production and reproduction of sound in this way, the "photophone," because an ordinary beam of light contains the rays which are operative.

It is a well-known fact that the molecular disturbance produced in a mass of iron by the magnetizing influence of an intermittent electrical current can be observed as sound by placing the ear in close contact with the iron. It occurred to us that the molecular disturbance produced in crystalline selenium by the action of an intermittent beam of light should be audible in a similar manner without the aid of a telephone or battery. Many experiments were made to verify this theory, without definite results. The anomalous behavior of the hard-rubber screen suggested the thought of listening to it also. This experiment was tried with extraordinary success. I held the sheet in close contact with my ear, while a beam of intermittent light was focused upon it by a lens. A distinct musical note was immediately heard. We found the effect intensified by arranging the sheet of hard-rubber as a diaphragm, and listening though a hearing-tube. We then tried crystalline selenium in the form of a thin disk, and obtained a similar but less intense effect. The other substances which I enumerated at the beginning of my address were now successively tried in the form of thin disks, and sounds were obtained from all but carbon and thin glass. We found hard rubber to produce a louder sound than any other substance we tried, excepting antimony, and paper and mica to produce the weakest sounds. *On the whole, we feel warranted in announcing as our conclusion that sounds can be produced by the action of a variable light from substances of all kinds, when in the form of thin diaphragms.* We have heard from interrupted sunlight very perceptible musical tunes through tubes of ordinary vulcanized rubber, of brass, and of wood. These were all the materials at hand in tubular form, and we have had no opportunity since of extending the observations to other substances.

I am extremely glad that I have the opportunity of making the first publication of these researches before a scientific society, for it is from scientific men that my work of the last six years has received its earliest and kindest recognition. I gratefully remember the encouragement which I received from the late Professor Henry at a time when the speaking telephone existed only in theory. Indeed, it is greatly due to the stimulus of his appreciation that the telephone became an accomplished fact. I can not state too highly also the advantage I received in preliminary experiments on sound vibrations in this building from Professor Cross, and near here from my valued friend Dr. Clarence J. Blake. When the public were incredulous of the possibility of electrical speech, the American Academy of Arts and Sciences, the Philosophical Society of Washington, and the Essex Institute of Salem recognized the reality of the results, and honored me by their congratulations. The public interest, I think, was first awakened by the judgment of the very eminent scientific men before whom the telephone was exhibited in Philadelphia, and by the address of Sir William Thomson before the British Association for the Advancement of Science.

At a later period, when even practical telegraphers considered the telephone as a mere scientific toy, Professor John Peirce, Professor Eli W. Blake, Dr. Channing, Mr. Clarke and Mr. Jones, of Providence, Rhode Island, devoted themselves to a series of experiments for the purpose of assisting me in making the telephone of practical utility; and they communicated to me, from time to time, the result of their experiments with a kindness and generosity I can never forget. It is not only pleasant to remember these things and to speak of them, but it is a duty to repeat them, as they give a practical refutation to the oft-repeated stories of the blindness of scientific men to unaccredited novelties, and of their jealousy of unknown inventors who dare to enter the charmed circle of science. I trust that the scientific favor which was so readily accorded to the telephone may be extended by you to this new claimant, the photophone.

EDUCATION AS AN AID TO THE HEALTH OF WOMEN.

By ELIZABETH CUMINGS.

"In education we should endeavor to make a man change from one habit to a better."—THEÆTETUS (PLATO).

THE relation between physical and psychical states is so intimate, and the effects of the latter so nearly simulate disease, that physicians are often led into grave errors in diagnosis and treatment. Nor is this the worst mischief; the secondary stage of psychical excitement may be actual disease, for the nerve-force expended is so much withdrawn from the processes of nutrition and assimilation, and continued morbid action of any of the functions has a tendency to establish organic change. How far education may act as a conserver of psychical, and secondarily of physical health, is therefore a legitimate object of inquiry.

Subject as the female organism is to a periodicity of alternate excitation and depression, the nervous system must respond in a degree to the increased or lowered tension of the veins and arteries. To this physiological cause of emotional excitability are added the effects of habitual in-door life, unhygienic dress, and avocations that are puerile, or that tax the physical strength to the utmost. Instead of correcting the natural tendency, the habits and pursuits of women superimpose upon it an acquired nervous sensibility and irritability, till lack of nerve equilibrium has come to be inherent in civilized women, and Sydenham, generalizing from this point, says, "All women are hysterical"—an assertion that thinking women, especially the mothers of girls, would do well to consider.

The social environment of women is, in its effect, somewhat like the drug mentioned by Dr. Clark in his volume on "Visions," that, taken into the system, paralyzes the nerves of motion, but leaves the nerves of sensation unaffected. An appearance of well-being and content is required of them, at the same time they are exposed, much more than men, to the hurts and wounds that touch what we call the feelings. Without the diversion of work that employs their intellectual faculties, they are constantly tempted to magnify the torments of wounded self-love and the petty griefs that a properly developed nature would not consider. Religion is their only solace, and that incites them to bear their troubles in the martyr spirit, that is, by sheer force of will, an effort that has a markedly anti-vital effect upon the organic functions, rather than with the "sweet reasonableness" which regards harassments as the common lot of all, and therefore determinately turns the attention away from them to higher things.

Though education must for ever work within limits, and can never go beyond the capacity of the individual nature, one can, by strict watchfulness over self, and exercising the will in the required direction, insensibly bring about such a habit of thought, feeling, and action, as he may wish to attain to, his ideal being only a foreshadowing of his own possibilities. To assist one to so train his mind and to furnish him with noble and suitable objects of study is one of the highest offices of a wise education; and that women especially need the help afforded by such training is evidenced by the long list of female patients, suffering from some form of neuropathic disease, that the busy physician carries on his books.

To the uninitiated, hysteria stands for simple foolishness; to the physician, it represents a hydra, hundred-headed, and the parent of yet more serious disorders. There is scarcely a type of disease that it will not simulate. It will even take on the forms of articular rheumatism and spinal disease, and will cause syncope apparently as profound as that induced by organic disease of the heart. It does not limit itself to one attack, for the tendency the automatic apparatus of the body has to repeat its acts will cause the second expression of excitement to be more easily induced, more ungovernable, and more prolonged than the first. And, the hysterical diathesis established, the patient may yield to such seizures till morbid processes set up in the brain and spinal cord. Its effects do not stop with the individual. Lack of voluntary direction of the thoughts and feelings, and yielding to melancholy and depressing passions in the mother, in her resulting in neuropathic states, may exhibit remote effects in her offspring as chorea, epilepsy, or an appetite for spirituous liquors. And it is not too much to say that these diseases and even insanity are often but differing results of a weakening of the nerves and nerve-centers, having ultimately in the mother a psychic cause. For the cure of hysteria and allied complaints physicians declare that skillful mental treatment is better than all the drugs in the pharmacopœia. The recoveries that take place through sympathy, mesmerism, and miracle-mongers, are easily explained when one discovers that diseases, whose remote causes are nervous, often yield instantaneously to appropriate psychical treatment. But better than any remedy is prevention, and, if the mind can exercise a curative influence over an unstrung nervous system, there is no doubt that, by means of proper physical, mental, and moral training, the predisposition to neuropathic complaints, which specialists declare universal in women, may be very nearly extinguished.

A family that came specially under my notice will illustrate the effect of the psychic states of the parent upon the offspring. The father, a full-blooded animal of a man, had a most brutal temper. The mother, a delicate woman of nervous temperament and submissive disposition, used up her nervous energy keeping her husband pleasant, or enduring his passion. Besides his ungovernable temper, the father had no vices ; the mother came of a healthy but somewhat nervous family, who were remarkably religious.

There were five children, three of whom were sons. The eldest inherited his father's temper, was a libertine, and fond of drink. The second son died of delirium tremens ; and the third, having squandered his strength and fortune upon women and drink, shot himself. The older daughter, a pale and slender woman of most saintly spirit, gave birth to two children ; the first died in infancy ; the second lived till the age of puberty, and then went into a rapid consumption. The younger daughter was, during middle life, subject to a periodic insanity, and one of her three children, after suffering from chorea for years, lapsed into idiocy.

Of the family of the oldest son I can only speak with certainty of two. One of his sons had epileptic fits, and one daughter had anger-fits quite like her venerable grandfather, when she would swear with a volubility a trooper might envy. These explosions of temper usually ended in hysterical convulsions. Curious to know more, I inquired of a gentleman, an old acquaintance of the family, what sort of a mother old Mr. Blank had. "Oh, she was a nice old lady when I knew her, though she had spells, and, when she was younger, I've heard them say her spells were awful," was the reply. "What kind of spells?" I asked. "I don't know. When I knew her, anything that crossed her, or made her feel bad, would set her going. She seemed to faint, and would go from one fit to another, till sometimes it was hours afore she was herself. She said she felt as if she was choking, and the doctors gave her no end of 'fæta pills,' but she always had spells till she died." "Were you acquainted with Mrs. Blank's family?" I asked, still curious. "Oh, yes, knew them well," said the old man with an air of marked respect. "They were excellent people. The old lady, Mrs. Blank's mother, was very religious, and at camp-meetings was a master hand at having the power. Oh, she was good, and the right sort."

I do not say that if these mothers had not yielded their self-control, the one to hysterics, the other to religious enthusiasm, all the train of evils that appeared in the family I have described would not have happened ; but I am sure I keep within the limits of probability if I assert that determined self-control and self-government on their part would have been markedly influential in producing a corresponding nerve-strength and self-control in their offspring.

The radical defect in the education of girls is, that knowledge, and that of a very superficial sort, instead of the cultivation of the faculties, is made its aim. Regarded by the large majority of educators in a partial light as a means organized for something outside of herself, the girl is simply taught to appear educated. The directing of her mind into a wholesome and self-controlled activity, which is the only means of perfecting the intellectual faculties, is not thought of. Her mind is made a scrap-bag into which are dropped the dabs of this and that which custom has decreed a young woman should know, and which she and her friends regard very much in the same light as the bows and feathers on her pretty bonnet.

Between the ages of twelve and twenty, the time of all others when her body and its healthful development ought to be carefully looked after, a girl ordinarily receives all the intellectual training she ever has. To do credit to the school and satisfy the mistaken pride of her friends, she is kept in a perpetual hurry, memorizing an incredible number of pages per day. Her chief recreation is a sedate walk, in which dress and behavior have to be considered more than the toning up of her flabby muscles and the oxygenizing of her thin blood. Her chief pleasures are evening entertainments, where her vanity is stimulated to the utmost, and late hours, unhygienic dress, and unwholesome food tax her vitality.

Society emphasizes the education of the boarding-school. To appear well is its sole demand upon young women. Earnestness, an interest in the projects which their founders believe will regenerate the world, all the ebullitions of force characterestic of the young mind that thinks, even an enthusiasm for study, are "bad form" for a young lady in society, and make her suspected of being, at least, "queer." Of course, I speak of ordinary society. There are cultivated congeries in every large city in which more is expected of a girl than mere prettiness. A bright girl who has finished her school-life scarcely knows what to do with herself. Her education was not a preparation for any special work, and, unless she was very fortunate, it did not lay the foundation of proper mental habits. The intellectual in her has been roused, but she has not been taught how to direct it. Some way this force will expend itself: if it can not find a legitimate outlet, it will stimulate the emotions, and find a disastrous activity in them, and too often the "sweet girl-graduate" becomes a sentimental creature, a prey of whims and caprices, capable of an intense but one-sided energy when her enthusiasm is roused, but incapable of any sustained, self-directed effort.

Women rarely find in marriage greater incentives to a real intellectual activity than they find in the boarding-school or in society. Whether the man whose name she takes will be as attractive in middle life as in his youth—whether she will be proud and glad that he is the father of her children—are matters about which the young girl is not taught to think. Domestic economy, as now carried on, is burdensome and full of distasteful and humdrum duties. Having no special aptitudes, not having enough control of her mind to elect to do anything, or to persist in it if she so elect, not knowing how to make the most of what is open to her, unhappiness, real or imaginary, preys upon the average woman to an extent not to be guessed at by a person whose mind is employed.

It is the natural tendency for those powers which are constitutionally the strongest to overrule and weaken the others. If woman is, from physiological causes, more emotional than is good for her, and the habits of civilized life have increased this tendency, if emotional excitement weakens the control which the will ought to exercise over the powers of attention and reflection that stand at the head of intellection, it is the first business of the teacher to employ a girl's faculties as equally as possible—to restrain those which unduly predominate, and exercise the weaker powers.

A girl should be made to understand, from the first, that the education she receives at school is to do for her mind what the scales and exercises do for her fingers in her musical studies; that she is not to study simply to acquire facts, but to get control of her mind. Moreover, she should be taught that it is her duty to look forward to a life-long intellectual activity, so that, when she comes to take full charge of herself, she will direct her mature powers toward some pursuit or line of study which will promote her present or future welfare, and insure to her wholesome mental habits. Especially should her will-power, the force which will, more than any other, make or mar her, receive the most careful training; so that, become adult, she will be able to use it physiologically, and determinately turn from the enemies, wounds, and serious sorrows, that otherwise might induce nervous disease, or drive her into a mad-house, to some one of the many subjects of interest in which the world abounds.

The first mistake in the education of girls, and the one fraught with the saddest results, is made when they are allowed to leave childhood too soon. To keep them little girls as long as possible, and make them, first of all, what George MacDonald calls "blessed little animals," is the first step in the right direction.

The second mistake is, permitting growing girls to sit in the house and study when their transparent cheeks tell of anæmia and lowered vitality. So long as there are branches of knowledge which are admirable training for the mind and can be pursued best out of doors, this mistake is inexcusable. It remains to be seen whether the old methods of education in use in boys' schools are the best for girls: they are best only if they are most physiological. Girls should be treated as they are, not as they might be under improved habits and conditions.

The third mistake is, making the school-life of girls final, when it ought to be a simple preparation for the intellectual life of the adult woman.

A fourth mistake is, withholding a knowledge of the laws to which woman is subject, in her physical and her mental life, her place in nature, and the potential character of her mental states and habits.

ON THE DESTRUCTION OF INFECTIOUS GERMS.

By Dr. A. WERNICH.

THE theory that contagious diseases as well as putrefaction and fermentation are developed and propagated by the agency of organisms allied to the bacteria has been widely accepted, and is supported by the results of recent investigations. It becomes, then, of paramount importance to ascertain the most efficacious means of destroying these organisms.

With this object in view, these researches into the conditions under which bacteria may be destroyed have taken three directions: 1. To test an observation made by Ernst Baumann, that the putrefactive organisms in the course of their action develop carbolic acid, a deadly poison to them, and to inquire whether there are not other poisons to bacteria developed in a similar manner; 2. Investigations prosecuted during the prevalence of the plague to ascertain whether a dry disinfection of clothing and goods could be made effective wholly to destroy the infectious organisms; 3. Having transplanted active infectious organisms from one substance to another to which they are suited, to arrest them in the most rapid stage of their development, destroy them, or cause them to perish.

In order to make the experiments of real value, a sure means must be found of knowing whether the organisms are alive or dead; they may seem dead when they are only passive. The only unfailing test is afforded by the reproductive faculty: when reproduction ceases, and can not be excited, the organisms may be considered dead.

Particular investigators have doubted whether it is possible wholly to destroy these lower organisms. Naegeli * says it can not be fully done without the aid of heat, and even heat is not always equally effective. They are generally more easily destroyed by heat when moist than when dry, but even a boiling heat will not destroy some of them when they are in fluids of a neutral reaction. The more acid the reaction, the less is the degree of heat that is required. The degree of heat required to destroy the germs of infectious diseases is believed to be greater than it is practicable to apply by the dry process to clothing and similar materials. The capacity of many of the organisms to reproduce may, indeed, be destroyed by a more moderate temperature, but a question remains concerning the germs or spores which had been taken up into the materials and were carried away with them. These are believed to have some kind of a coating which enables them to resist what destroys the parent organisms.

In order to test the value of the dry process as applied to infected

* Die niederen Pilze in ihren Beziehungen zu den Infektionskrankheiten und der Gesundheitspflege, s. 201.

clothing, pieces of different clothing materials were impregnated with strong putrefying and bacteria-bearing fluids, then dried slowly, and kept for a long time without protection against external influences. Whenever the smallest piece of one of these materials was put into a suitable fluid, the perturbation invariably took place which is the sure sign of the active multiplication of bacteria. Clothing which had not been impregnated did not excite this perturbation, or only in an insignificant degree. Specimens of the defiled clothing which were placed in a similar solution after they had been exposed for five minutes to a temperature of from 125° to 150° C., or for one or two minutes to a higher temperature, produced no change. The capacity of the bacteria to resist heat varies widely among the different species, and appears to depend largely on the faculty of developing spores. The individuals are killed, but the spores remain vital. The increase of any one kind is limited by the presence of other kinds, with which a struggle for existence has to be maintained.

No increase of bacteria takes place without the presence of a suitable substance to support them. The most favorable of non-nitrogeneous substances is sugar; among nitrogeneous substances the most favorable are the albuminoids; among mineral matters, potash, phosphorus, magnesia, and sulphur. If the supporting substance, even though it is needed in only a minute quantity, is consumed, or if it is present in great excess, a pause in the development, but not the death of the bacteria, takes place. A similar effect is produced by taking away the water, but, when the water is restored, an increase of life again takes place.

The practical object of disinfection should be to go beyond securing a suspension of animation of the bacteria, and to seek to destroy the vitality of the spores. Neither years of dryness, nor months of exposure in foul water, nor repeated drying and moistening, will injure the fertility of these germs.

An excess of water produces a similar effect with desiccation upon the vital conditions of the bacteria. A great dilution of the supporting fluid by the infusion of pure water will in a short time produce a suspension of the process of decomposition. Privation of light has no effect. The operation of electricity has not been enough observed to justify the drawing of any conclusion. The effect of the privation of air has not been fully determined. It was once thought that the development of bacteria could be hindered by the removal of oxygen, but this is doubtful. Oxygen greatly speeds the development, but it can take place without it. Bacteria are not developed in nitrogen, hydrogen, carbonic oxide, carbonic acid, nitrous oxide, and illuminating gas.

The substances which are fatal to the life of the bacteria next demand attention. Among these, the concentrated mineral acids, iodine, bromine, chlorine, the sulphates of copper and zinc, corrosive sublimate, benzoic acid and its salts, salicylic and metasalicylic acids, quinia, many aromatic substances, and alcohol, have long been known as such. Carbolic acid is the highest in repute among these poisons; and it is an interesting fact that Mr. E. Baumann has discovered this very substance among the products of the bacterian fermentation to which it is so fatal. Alcohol is another substance similarly associated. The discovery of the curious relations of these two substances gives a new light upon the cause of the spontaneous destruction of bacteria in strongly fermenting fluids, and encourages us to look for other substances having a similar origin and a like action. As evidence of the possession of such properties by any substance, we should require—

1. That substances favorable to the development of bacteria should remain free from them when the substance to be tested is added to them.

2. That active bacteria, when transplanted into a supporting mixture to which a substance supposed to be poisonous to them has been added, should cease to propagate themselves and die out. This may be called the aseptic test.

3. That, when the supposed poison is introduced into a solution swarming with bacteria, all living examples should be killed. This may be called the antiseptic test.

Various aromatic substances, the products of fermentation, were added to a mixture of water and chopped meat at a temperature of 35° C. They proved efficacious in preventing, suspending, or wholly stopping decomposition in the following order, according to the strength of their working:

1. As Preventives of Decomposition:

Indol	in a proportion of	1 : 1,000	of the mixture.
Kresol	"	"	2 : 1,000	"
Phenylacetic acid,	"	"	2·5 : 1,000	"
Carbolic acid	"	"	5 : 1,000	"

(The working of scatol and hydrocinnamic acid could not be satisfactorily ascertained, on account of the difficulty of dissolving them in water.)

2. As Aseptics—killing transplanted organisms by poisoning the supporting fluid:

Scatol............	in a proportion of		0·4 : 1,000	of the mixture.
Hydrocinnamic acid	"	"	0·6 : 1,000	"
Indol.............	"	"	0·6 : 1,000	"
Kresol............	"	"	0·8 : 1,000	"
Phenylacetic acid ..	"	"	1·2 : 1,000	"
Carbolic acid......	"	"	5 : 1,000	"

3. As Antiseptics—wholly destroying all living bacteria:

Scatol, in the proportion of 0·5 : 1,000 of the mixture, in twenty-four hours.

Hydrocinnamic acid, in a proportion of 0·8 : 1,000 of the mixture, in twenty-four hours.

Phenylacetic acid, in a saturated solution (1 : 400), immediately.
Indol, in a saturated solution (1 : 900), in twenty-four hours.
Kresol, in the proportion of 5 : 1,000 of the mixture, in twenty-four hours.
Carbolic acid, in the proportion of 20 : 1,000 of the mixture, immediately.

Two points strike us in this review: first, the difference in the amount of poison required to produce the aseptic and the antiseptic effect; again, it is curious that carbolic acid, the favorite antiseptic, appears to be the weakest on the list. It is at the same time one of the most soluble, while scatol, the most difficult of solution, is the strongest.

If we add the substances we have been examining to a saccharine solution exposed to fermentation, a slackening of the fermenting process will take place, and the different substances will, as before, exhibit their power to delay the process in the following order: scatol, hydrocinnamic acid, indol, phenylacetic acid, kresol, carbolic acid.

These facts seem to justify us in looking for specific disinfectants and prophylactics among the aromatic products of chemical decomposition. They also give a strong air of plausibility to the theory that the bacteria produce, through the chemical changes of which they are the direct cause, the most effective substances that can be used to destroy them. The idea is logically deducible from this theory that the germs of disease finally produce their own destruction by the operation of their growth and development, and helps us to comprehend the cyclical course which is characteristic of most infectious diseases.

POSSIBLE EFFICIENCY OF HEAT-ENGINES.

By Professor WILLIAM A. ANTHONY.

THE theory of thermodynamics, which asserts the equivalence of heat and mechanical work, has now been generally accepted by men of science for thirty years. The equivalence of heat and work is accepted as an established fact by engineers and mechanics, and the mechanical equivalent of heat, as determined by Joule, is made the basis of computations regarding the energy of fuel, etc., by practical men, without a question as to its correctness. But there is one conclusion to which the theory leads, of great practical importance as regards the theory of steam-engines, which does not seem to have been as generally accepted, and yet it is just as firmly established as the fundamental principle of the equivalence of heat and work. A pound of carbon by its combustion in oxygen yields 14,400 heat-units, equal to $14,400 \times 772 = 11,116,800$ foot-pounds of energy. One horse-power should, therefore, be developed by the combustion of about one sixth of a pound of carbon per hour, while our best steam-engines require about two pounds of coal per hour per horse-power. Hence it is said that the steam-engine is a very inefficient machine, which the genius of the future inventor may improve till a pound of coal is made to yield six, eight, or ten times the power it now gives.

But, while the theory of thermodynamics asserts that the combustion of a pound of carbon yields an amount of heat equivalent to 11,116,800 foot-pounds of energy, it also asserts just as clearly and just as firmly that, under the conditions which exist upon this planet, heat can not be transformed into mechanical effect without wasting a considerable portion of the energy due to it. In other words, if a given quantity of heat be taken from a source, as a steam-boiler, and made to do work by means of any form of engine, a considerable portion of that heat *must, from the very nature of things under existing conditions*, be allowed to pass through the engine and raise the temperature of other bodies to no useful purpose. It is to the discussion upon which this conclusion is based that I propose to devote this article.

In a very valuable essay published in 1824, Carnot furnished us with a conception which is an exceedingly useful one in this investigation. It is that of an engine completely reversible in all its physical and mechanical agencies. A water-motor which could be driven backward by means of some source of power, and would then raise to a given level as much water as it would use from that level to develop the power required to run it backward, would be a reversible engine. It is plainly to be seen that such a motor would be a perfect motor, and also a perfect pump. A reversible heat-engine would be one which, running forward and performing a certain amount of work by means of a given amount of heat derived from a source, would, if run backward by the performance *upon it* of the same amount of work, restore to the source the same amount of heat.

A reversible engine in this sense is, of course, impossible in practice, but the theoretical deductions from the conception are in no way invalidated by this fact. Such a heat-engine would be a perfect engine in the sense that it would produce as much mechanical effect as could be produced by any heat-engine under the same conditions from the same quantity of heat. The proof of this proposition rests upon two assumptions that are supported by all past experience, and may, therefore, be regarded as physical axioms: 1. That a perpetual motion is impossible; 2. That it is impossible by means of inanimate material agency to derive mechanical effect from any portion of matter by cooling it below the temperature of surrounding objects.

A heat-engine when at work must carry heat from a body of high temperature (the source) to one of low temperature (the refrigerator), and experiment has proved that the amount of heat given to the refrigerator is always less than that taken from the source. Now, let there be two heat-engines, *A* and *B*, of which *B* is reversible, working between the same source and refrigerator. Let each take the same quantity, H, of heat from the source, and, if possible, let A derive from this heat more work than B. Let h be the quantity of heat carried to the refrigerator, and W the mechanical effect developed by B when running forward. Let W', greater than W by hypothesis, be the mechanical effect developed by A. A may be used to run B backward, and, since B is perfectly reversible, will, in so doing, by the expenditure of the mechanical effect W, take from the refrigerator the amount h, and carry to the source the amount H of heat. The two engines so coupled would then develop the mechanical effect $W' - W$, while no heat would be lost by the source. If A carries to the refrigerator the same quantity of heat that B takes away, the mechanical effect $W' - W$ is developed without any change in external objects, without any consumption of energy. This would constitute a perpetual motion, which, by the first axiom, is impossible. If A transfers to the refrigerator less heat than B takes away, the refrigerator will grow colder and colder, and, since for the purposes of this discussion all other bodies may be assumed to be at the same temperature as the source, this will present the case of a machine producing mechanical effect while taking heat from the coldest of surrounding bodies. This is contrary to the second axiom. Therefore, A can not do more work under the conditions named than B. The reversible engine, then, derives as much mechanical effect from a given amount of heat as can be derived by *any heat-engine whatever* working between the same temperatures.

It follows further that all reversible engines working between the same source and refrigerator, and taking from the source the same amount of heat, must yield the same mechanical effect; in other words, must have the same efficiency. No matter what the working substance, or in what way heat is made to yield mechanical effect, so long as the process is completely reversible, the same amount of mechanical effect will always be derived from the same heat taken from the source.

It may be well to emphasize a little the first conclusion, that no heat-engine whatever can be more efficient than a reversible engine. If the reasoning is correct, no form of heat-engine, whether using air, or gas, or a condensable vapor, or a liquid, or a solid, as the working substance, or using thermo-electric currents, or any other means of converting heat into mechanical effect, can be more efficient than any one of the reversible engines. There is no escaping this conclusion except through the perpetual motion, or the derivation of mechanical effect from the heat of a body already cold. It has been sometimes claimed that the latter alternative was no impossibility, that the expansion of a compressed gas, the expansion of a gas into a vacuum, or the diffusion of one gas into another, may perform work at the expense of its own heat, while being cooled down to a lower temperature than surrounding bodies. But to compress the gas, or produce the vacuum, or separate the gases preparatory to diffusion, requires an expenditure of energy at least equal to the mechanical effect to be derived.

Since the reversible engine is as efficient as any heat-engine, and since all reversible engines of whatever construction and whatever the working substance have the same efficiency, it is allowable, in discussing the question as to the amount of mechanical effect derivable under given conditions from a given amount of heat, to assume any form of reversible engine, using any working substance which may be most convenient. And it makes no difference whether the engine assumed be practically possible, so long as we know the properties of the working substance well enough to determine its action under the assumed conditions. Sir W. Thomson, before 1851, assuming Carnot's engine with air as the working substance, furnished us with a very complete discussion of this question. The properties of air in relation to heat are very simple. Heat expands and cold contracts it with great uniformity. Compression heats and expansion cools it according to a well-known law. The effects of any change of volume or of temperature in the cylinder of an engine can, therefore, be exactly predicted.

Suppose a given mass of air to be compressed and the heat developed by compression removed, so that its temperature remains constant. The pressure exerted by it will increase, as shown graphically in the annexed diagram, where $O\ a$, measured on the horizontal axis $O\ x$, represents the initial volume, and $a\ e$ perpendicular to $O\ x$ represents the pressure exerted at that volume. $O\ b$, $O\ c$, and $O\ d$, represent other volumes, and $b\ f$, $c\ g$, $d\ h$, the corresponding pressures. The curved line $e\ f\ g\ h$, drawn through the extremities of the perpendiculars, represents to the eye the relation between volume and pressure *when temperature is constant*. It is called an *isothermal line*. Now, suppose the air to be compressed without loss or gain of heat. It is warmed by compression, and the rise of temperature causes it to exert a greater pressure. If, then, the substance be at the same initial volume, pressure, and temperature as before, and it be compressed to the volume $O\ b$ without loss of heat, the pressure exerted will be $b\ m$ greater than $b\ f$. Similarly the pressure $c\ n$ will correspond to the volume $O\ c$, and $d\ o$ to $O\ d$. The line $l\ m\ n\ o$, which shows the relation between volume and pressure *when no heat enters nor escapes*, is called an *adiabatic line*.

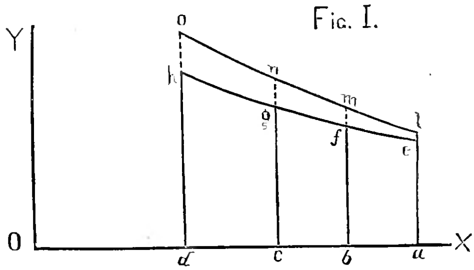


Fig. 1.

Carnot's engine consists of a cylinder having no outlet nor inlet, with an air-tight piston inclosing a mass of air which changes in volume with the movements of the piston. The piston and sides of the cylinder are supposed to be perfect non-conductors, while the bottom of the cylinder is a perfect conductor of heat. The engine has a source of heat and a refrigerator, whose temperatures are supposed to remain absolutely constant whether parting with or receiving heat. There is also a non-conducting stand, on which, if the cylinder be placed, no heat can enter or escape from it, however much the air within it may change in temperature. In the working of the engine there are four operations, as follows:

First Operation.—The air is supposed to be at the temperature of the refrigerator, which may be designated by t, and to have a volume represented by $O\ a$, and pressure represented by $a\ A$ (Fig. 2). The cylinder is supposed to stand upon its non-conducting support. The piston is now depressed, and, since no heat can escape, the air rises in temperature. The compression continues till the temperature of the air becomes that of the source, which we designate by T. The rise in pressure will be represented by the *adiabatic* line $A\ B$. Let $O\ b$ represent the volume and $B\ b$ the pressure at the end of the operation. It is plain that work must have been done to compress the air, equal to the space swept through by the piston multiplied by the mean pressure; but this is represented by the area of the figure $A\ B\ b\ a$.

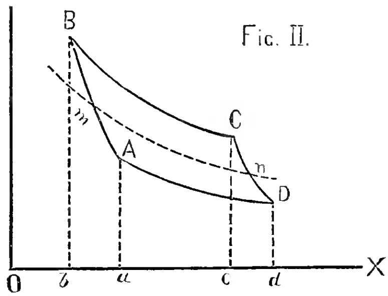


FIG. 2.

Second Operation.—The cylinder is placed upon the source of heat and the piston allowed to rise, being forced upward by the pressure of the air. The bottom of the cylinder being a perfect conductor, heat will enter so rapidly as to maintain the temperature of the air while it expands. The pressure therefore falls, as indicated by the *isothermal line* $B\ C$. Let this operation continue until an amount of heat H is taken from the source, and suppose $O\ c$ to represent the volume and $c\ C$ the pressure of the air at that time. It will be seen that during this operation work represented by the area $B\ C\ c\ b$ will have been done *by the air.*

Third Operation.—The cylinder is returned to its non-conducting support. The upward stroke of the piston continues, and the air expands without receiving heat, until its temperature falls to that of the refrigerator, that is, to the temperature that it had at the beginning of the first operation. The fall of pressure is represented by the *adiabatic* $C\ D$, and work represented by the area $C\ D\ d\ c$ is done *by the air.*

Fourth Operation.—The cylinder is placed upon the refrigerator, the piston caused to descend, and the air compressed until its initial volume is reached. Since the bottom of the cylinder and the refrigerator are supposed to be perfect conductors, the heat generated by the compression will escape to the refrigerator, and the temperature of the air will remain constant. The air is now in the same condition as regards temperature, volume, and pressure, as at the beginning of the first operation. The *isothermal line*, which represents the rise of pressure during the last operation, must, therefore, pass through the starting-point *A*. During this operation work represented by the area *A D d a* must be done upon the air, *and a certain amount of heat—all that generated by compressing the air—must be given up to the refrigerator.*

It will be noticed that, during the second and third operations, work represented by the area *B C D d b is done by the air*, and during the first and fourth operations work represented by *B A D d b is done upon the air.* During the complete cycle of operations, therefore, mechanical effect is developed equivalent to the difference between these areas, or to the area *B C D A*. This figure is, in fact, the indicator diagram of the engine. During the second operation, heat represented by *H* was taken from the source, and during the fourth operation heat represented by *h* was given to the refrigerator. During the cycle of operations, heat equal to $H-h$ has disappeared, and, since the working substance is at the end of the cycle in precisely the same condition as at the beginning, this heat must be the equivalent of the mechanical effect developed, and the efficiency of the engine is $\frac{H-h}{H}$

But it is easily shown that this cycle of operations is a completely reversible cycle. For suppose the substance at its initial volume *O a*, pressure *A a*, and temperature *t*. Place the cylinder on the refrigerator, and allow the air to expand to the volume *A d*. The same isotherm *A D* that represented the rise in pressure in the reverse operation will now represent the fall, and the same heat *h* that was before given to the refrigerator will now be taken from it. Now let the cylinder be placed upon its non-conducting support and the piston descend till the volume becomes *O c*. Since no heat escapes, the rise of pressure will be represented by the adiabatic *D C*, and the temperature will rise by the same amount as it fell during the expansion from *c* to *d*, that is, from *t*, the temperature of the refrigerator, to *T*, that of the source. Now, let the cylinder be placed upon the source, and the descent of the piston continue till the volume of the air becomes *O b*, the temperature remains that of the source, the isotherm *C B* represents the rise in pressure, and heat is given to the source precisely equal to the amount taken from it during the expansion from *b* to *c* in the direct working of the engine. Now let the cylinder be placed upon its non-conducting support, and the piston rise till the volume becomes *O a*.

Since no heat can enter, the temperature will fall to t, and the pressure to $A\,a$. It is easy to show that, during this reverse cycle, an amount of mechanical energy represented by $A\,B\,C\,D$ has been expended, and it is seen that heat equal to h has been taken from the refrigerator, and heat equal to H given to the source. The engine is, therefore, a perfectly reversible engine in the sense before defined, and it has already been seen that no other heat-engine of whatever construction, steam, gas, hot air, thermo-electric, or whatever it may be, working between the same temperatures, could develop more mechanical effect from the heat H taken from the source. In other words, any heat-engine working between the temperatures T and t, and taking from the source the amount H of heat, must transfer to the refrigerator an amount of heat at least equal to h, the amount given up by our reversible engine under the same conditions. It remains to be seen what relation this bears to the heat taken from the source.

Experiment proves that the lower the temperature the smaller is h, and it is evident that if the temperature of the refrigerator had been lower the isotherm $A\,D$ would have been $O\,X$. The area $A\,B\,C\,D$ would then be greater, and, since this represents the work done by the engine in one revolution, it is seen that this is greater the lower the temperature of the refrigerator. It appears, then, that the proportion of the heat taken from the source which can be converted into mechanical effect, is greater as the temperature of the refrigerator is lower, and the question arises, how low must this temperature be in order that the whole of the heat may be so converted. Perhaps the best way of approaching this question is by Sir W. Thomson's absolute scale of temperature. This may be defined as a scale upon which the temperatures of any two bodies are to each other as the heat received is to the heat rejected by a reversible heat-engine using one of the bodies as a source and the other as a refrigerator. That is, if T and t are the temperatures upon the absolute scale of our source and refrigerator, $T : t :: H : h$, or $T-t : T = H-h : H$.

Let T be the temperature of boiling water, and t that of melting ice, and let $T-t = 180°$, as in the Fahrenheit scale. From the properties of air we know that if it is used as the working substance of a reversible engine, with a source at the temperature of boiling water and a refrigerator at the temperature of melting ice, $H-h : H :: 100 : 373$ nearly. Hence

$$180 : T :: 100 : 373$$
$$T = 671{\cdot}4$$
$$\text{and } t = 491{\cdot}4.$$

Any other temperatures may be easily determined. Suppose $B\,C$ (Fig. 2) be the isotherm corresponding to the temperature of boiling water, $A\,D$ that corresponding to that of melting ice, and $m\,n$ an isotherm corresponding to some intermediate temperature, that marked 100° on the Fahrenheit scale, for instance, whose temperature t' upon the absolute scale we wish to determine. We have as above $T-t : T :: H-h : H$, and $T-t' : T :: H-h' : h'$, if h' is the heat rejected at the temperature t'. Hence $T-t : T-t' :: H-h : H-h'$. But $H-h$ is the heat converted into work by an engine working between the temperatures T and t, and is proportional to the area $B\,C\,D\,A$. Also $H-h'$ is the heat converted into work by an engine working between the temperatures T and t', and is proportional to the area $B\,C\,m\,n$. Therefore $T-t : T-t' ::$ area $B\,C\,D\,A$: area $B\,C\,m\,n$; or $180° : T-t' ::$ area $B\,C\,D\,A$: area $B\,C\,m\,n$.

Having the data for constructing the isothermal and adiabatic lines, the areas $B\,C\,D\,A$ and $B\,C\,m\,n$ can be computed, and hence t' determined. The divisions of an absolute scale so constructed are found to correspond very closely with the divisions of the air-thermometer, and to differ but little from the divisions of the Fahrenheit scale. We are led, then, to the conclusion that to convert all the energy of a given amount of heat into mechanical effect, a refrigerator at a temperature of 491 Fahrenheit degrees below the melting-point of ice, or 459° below zero Fahr., is necessary.

Let us recapitulate briefly the points of this argument.

1. It is impossible for any heat-engine, of whatever construction, to convert into mechanical effect a larger proportion of the heat derived from a given source than can be done under the same conditions by a reversible engine. This proposition can not be denied without involving a denial of two physical axioms which are founded upon the results of all past experience, viz.: That the perpetual motion is impossible, and that "it is impossible by means of inanimate material agency to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of surrounding objects."

2. That all reversible engines, whatever the working substance, have the same efficiency; that is, taking from the source the same quantity of heat H, they will transfer to the refrigerator the same quantity h, and convert into mechanical effect the same quantity $H-h$. Hence whatever results are derived from a discussion of any one form of reversible engine will be true of all others.

3. If a scale of temperature be constructed such that the temperature of the source is to the temperature of the refrigerator of a reversible engine as the heat derived from the source is to the heat given to the refrigerator, the scale divisions will differ but little from the divisions of the scales in common use. The efficiency of an engine will then be $\frac{T-t}{T} = 1 - \frac{t}{T}$.

4. Upon such a scale, if there are, as in the Fahrenheit scale, 180° between the freezing and the boiling points of water, the former point would be numbered 491·4 and the latter 671·4. The pos-

sible efficiency of an engine working between these two temperatures would therefore be $\frac{671 \cdot 4 - 491 \cdot 4}{671 \cdot 4}$, 27 per cent. nearly.

Heat-engines are often spoken of as very inefficient machines, because they transform into mechanical effect but a small proportion of the heat used. The inefficiency is not so much the fault of the machine as of the conditions under which it is worked. Consider the case of a condensing engine with a boiler pressure of 45 pounds and a vacuum of 25 inches of mercury. The temperature of the source is here about 294° and of the refrigerator 140° Fahr. The possible efficiency under these conditions is about 20 per cent., that is, a *perfect* engine working between those temperatures could give in mechanical effect no more than one fifth the energy of the heat. The best steam-engines would, under these circumstances, give one-horse power for something less than two pounds of coal per hour. This is an efficiency of 10 or 12 per cent., or more than half the possible efficiency. The engine, as a machine, is not so very imperfect. In speaking of the engine, I of course include the boiler as a part of the machine. Any great improvement must come from an increased range of temperature between the source and refrigerator. The temperature of the refrigerator can not well be lower than the general temperature of surrounding objects, and there are great practical difficulties in the way of a very high temperature of the source. Suppose an engine could be worked with a source at a temperature of 1250° of the absolute scale, or nearly 800° Fahr., and a refrigerator at 500° of the absolute scale, or nearly 40° Fahr., the possible efficiency would be $1 - \frac{500}{1250}$, or only 60 per cent. It appears, then, that there is not much hope that any large percentage of the energy of heat can, by any practical means, be converted into mechanical effect. But are we, for this reason, to continue wasting the energy of fuel as it is wasted now? Is there no other way in which the energy of chemical separation of carbon from oxygen can be converted into mechanical effect except by first converting it into heat? Why may not the union of carbon with oxygen be made to generate electric currents instead of heat? Electric energies have been made that convert into mechanical effect 60 to 70 per cent. of the energy of the electric current, and a much higher efficiency might, no doubt, be obtained. Already something has been done toward the generation of electric currents by the union of carbon and oxygen; but, so far, no means has been discovered by which such a union can be effected, except at a high temperatnre, and this involves a great waste of energy in the form of heat. A discovery that would enable us to convert the energy of fuel into electric currents directly and completely would revolutionize, not only the methods of obtaining power, but the methods of obtaining light and distributing heat as well. I have shown elsewhere that, if a Brayton oil-engine is used to drive a dynamo-electric machine producing the electric light, more than twice as much light will be developed as would be obtained if the oil that runs the engine were burned in the ordinary coal-oil lamps. How much greater would be the economy if the energy of the oil could be converted directly into the energy of the electric current!

For warming buildings, the furnace would become an electric generator, from which wires, instead of pipes for steam or hot air, would lead to the rooms to be heated, when, by interposing a suitable resistance, the energy of the current would be converted into heat. The probability of being able to convert the energy due to combustion of fuel into electric instead of heat energy may be very small; but it is at least a possibility; that is, there is no known reason in the nature of things why it can not be done, while it is demonstrated that the whole of the energy of heat can not be converted into mechanical effect, except by means of a refrigerator at a temperature of nearly 500° below that at which water freezes—a temperature which has never yet been reached, and which it is impossible to obtain with our present surroundings, except by an expenditure of energy equal to that which would be gained.

SKETCH OF GEORGE BOOLE.

"AND pray who is George Boole, that he should be pictured and sketched in 'The Popular Science Monthly'? We thought this department was to be devoted to scientific celebrities, chiefly contemporaneous; but who is this Boole?"

Such will probably be the exclamation of nine of our readers out of ten; but the tenth, or more safely the hundredth, reader will know that George Boole was a man of a very high order of genius, a profound and most original thinker of this century, who will be known in future by his contributions to mathematical and logical science. Yet he can never be widely *known*, for his work was so recondite that those who can properly appreciate it will always be but very few. We gather the following particulars of his life from the last edition of the "Encyclopædia Britannica":

George Boole was born in Lincoln, on the 2d of November, 1815. His father was a tradesman of limited means, but of studious character and active mind. Being especially interested in mathematical science, the father gave his son early instruction in the rudiments of the science he was so greatly to advance; but it is remarkable that the extraordinary mathematical powers of George Boole did not manifest themselves in early life, as was the case with Zerah Colburn, Babbage, Pascal, Leibnitz, and Saunderson. The classical languages formed at first the favorite subject of his studies. It was not until he had attained his seventeenth year that he attacked the higher mathematics, and his progress was much retarded by the want of efficient help.

When about sixteen years of age he became assistant master in a private school in Doncaster, and he maintained himself to the end of his life in one grade or other of the scholastic profession. Few distinguished men, indeed, have had a less eventful career. Almost the only changes which can be called events are his successful establishment of a school at Lincoln; its removal to Waddington; his appointment, in 1849, as Professor of Mathematics in Queen's College, Cork; and his marriage, in 1855, to Miss Mary Everest.

His works are comprised in about fifty scattered articles and a few separate and individual publications. Only two systematic treatises on mathematical subjects were completed by Boole. These were a "Treatise on Differential Equations," which appeared in 1859, and was followed, next year, by a "Treatise on the Calculus of Finite Differences," designed to serve as a sequel to its predecessor. In the sixteenth and seventeenth chapters of the former work he lays down a lucid exposition of the symbolic method, the bold and skillful employment of which led to his chief discoveries.

Boole was one of the most eminent of those who perceived that the symbols of operation could be separated from those of quantity and treated as distinct objects of calculation. His principal characteristic was perfect confidence in any result obtained by the treatment of symbols in accordance with their primary laws and conditions, and an almost unrivaled skill and power in tracing out these results.

During the last few years of his life, Boole was constantly engaged in extending his researches, with the object of producing a second edition of his "Differential Equations," much more complete than the first edition; and part of his last vacation was spent in arduous study in the libraries of the Royal Society and the British Museum, for the purpose of acquiring a complete knowledge of the less accessible original memoirs on the subject. It must be always a matter of regret that this new edition was never completed. Even the manuscripts left at his death were so incomplete that Mr. Todhunter, into whose hands they were put, as literary executor, found it impossible to use them in the publication of a second edition of the original treatise, and printed them, as a supplementary volume, in 1865.

Profound and important as were Boole's discoveries in pure mathematics, his writings on logic may be considered as still more original. With the exception of De Morgan, he was probably the first English mathematician since the time of Wallis (1616–1703) who had also written upon logic; and his wholly novel views of logical method were due to the same profound confidence in symbolic reasoning to which he had successfully trusted in mathematical investigation. From the preface to his "Mathematical Analysis of Logic," printed as a separate tract in 1847, we learn that speculations concerning a calculus of reasoning had, at different times, occupied Boole's thoughts, but it was not till the spring of 1847 that a memorable logical controversy led him to put his ideas into a definite form. He afterward regarded this pamphlet as a hasty and imperfect exposition of his logical system, and desired that his much larger work, "An Investigation of the Laws of Thought," etc. (1854), should alone be considered as containing a mature statement of his views.

This is Boole's greatest work, and is an attempt to apply the symbols and operations of mathematics to logic and the laws of thinking. The object of the work, as stated by himself, is "to investigate the fundamental laws of those operations of the mind by which reasoning is performed; to give expression to them in the symbolical language of a calculus, and upon this foundation to establish the science of logic and construct its method; to make that method itself the basis of a general method for the application of the mathematical doctrine of probabilities; and, finally, to collect from the various elements of truth, brought to view in the course of these inquiries, some probable intimations concerning the nature and constitution of the human mind."

Of this work Professor Todhunter, in the preface to his "History of the Theory of Probabilities," speaks as "marvelous"; and, in similar language, Professor W. Stanley Jevons speaks of it as "one of the most marvelous and admirable pieces of reasoning ever put together."

It is often supposed that mathematicians are deficient in judgment and knowledge of other matters. In Boole this was not the case; for, though he published little except his mathematical and logical works, his acquaintance with general literature was wide and deep. Dante was his favorite poet, and he preferred the "Paradiso" to the "Inferno." The metaphysics of Aristotle, the ethics of Spinoza, the philosophical works of Cicero, and works of a kindred character, were frequent subjects of his study.

The personal character of Boole inspired all his friends with the deepest esteem. He was marked by the modesty of true genius, and his life was given to the single-minded pursuit of truth. Though he received a royal medal for his memoir ("Philosophical Transactions of the Royal Society," 1844), and the honorary degree of LL. D. from the University of Dublin, it may be said that he neither sought nor received the ordinary rewards to which his discoveries entitled him.

"On the 8th of December, 1864, in the full vigor of his intellectual powers," says W. Stanley Jevons, in his tribute to his friend's life and genius, "George Boole died of an attack of fever, ending in suffusion on the lungs."

The mathematical and logical works of Boole are by far too abstruse to admit of their being used as text-books in schools of even the highest grades; but as works of reference they are invaluable to advanced students and the special cultivators of pure mathematics and the profounder problems of logic.

EDITOR'S TABLE.

THE BOSTON SCIENTIFIC MEETING.

THE twenty-ninth annual meeting of the American Association for the Advancement of Science, which began on the 25th of August, in Boston, was in every respect a most successful affair, and will be memorable both in the history of the Association and to all who had the pleasure of attending it. A large amount of excellent scientific work was accomplished, as shown by the fact that no less than two hundred and eighty original scientific papers were entered for reading at the different sections. Many of these were able and valuable contributions to independent research, and they all evinced a strong and healthy activity of the spirit of investigation. The meeting was the largest ever held by this body. The session opened on Wednesday, and by the succeeding Tuesday evening nine hundred and seventy-nine persons were registered, and of these five hundred and ninety-five were new members. As a happy and novel consequence, there will now be some surplus funds for the Association to use in aid of important researches.

To say that Boston did justice to the occasion is not enough, for justice is a thing of degrees. Boston did splendid justice—redeemed every expectation, which is saying a good deal, and did that ample honor to science both in public and in private which science well deserves. Whatever could be done to facilitate the work of the Association and to make it pleasant for all its members was done. The hospitalities were cordial and profuse. The corporations of Boston and Cambridge and wealthy private citizens gave entertainments to the Association, which were luxurious, elegant, and in excellent taste. Free excursions were provided to all points of interest in the vicinity, and, when work was through, a large lot were sent off to the White Mountains in charge of the Apalachian Club. Every detail of preparation had been carefully attended to by numerous efficient committees, and the completeness of the smooth-working arrangements excited the admiration of all. It is hard to suit everybody, but we must say that this feat was for once accomplished. Even where idiosyncrasies were jostled, only smiles were elicited. Nine hundred and fifteen persons accepted the city's invitation to take a trip down the bay in a commodious steamer. A generous collation was provided in the cabin, and when the guests had partaken of it, as they passed to the deck above, each gentleman was presented with an envelope on which was stamped, "The City of Boston welcomes the American Association for the Advancement of Science." Each envelope contained three choice cigars, and we mention the fact merely to say that the most fanatical non-smokers benignly accepted the graceful attention, and either kept their little prize as a souvenir of the occasion, or enjoyed the cigars by presenting them to their favored friends. Whatever was interesting in Boston in the shape of institutions and attractive features was open to the members, and multitudes of them profited by the opportunity. Invitations were cordially extended to visit the American Academy of Arts and Sciences, the Massachusetts Historical Society, the Boston Society of Natural History, the Society of Decorative Art, the Warren Museum of Natural History, the Boston Public Library, the Athenæum Library, the commandant of the Charlestown Navy Yard, the

Metric Bureau, Tufts College, the Watertown, Arsenal, the Old South, and many other places of interest to strangers.

It has been objected that too much time is generally spent at these meetings in social enjoyment; but it is not to be forgotten that this is a cardinal object of the organization. It is both possible and desirable that in future years the management will be so improved that the social element without being impaired will be so regulated as to economize time and offer the least hindrance to the legitimate and solid work of the society. But the Association grew out of a social need which is more urgent, perhaps, in this country than in any other. The organization of the British Association for the Advancement of Science, half a century ago, was not only a very important movement in giving efficient direction to scientific labor, but it was an inevitable result of the growth of scattered activities which required to be brought into coöperative relations. It was found that scientific observers, experimenters, and discoverers are not mere eccentric and infatuated devotees, content to pass their lives in the cloistered seclusion of laboratories and observatories, but that they are normal human beings with social sympathies and necessities, who require to know each other and to be brought into relations of freer intercourse with the people. The British Association was formed for the promotion of the interests of science by systematizing the work of research, and by bringing large numbers of scientific men together annually for several days, and it was made migratory that its public influence might become effective in all parts of the country. The advantages of this associated action were real and important, and it was proved that the time had fully come to enter upon it. A new impulse was given to original study; there were new accessions to the ranks of scientific students, scientific work became more effective and efficient, and the people extended to it increasing encouragement and a more hearty and liberal support.

So successful was this plan of operations devised and carried out by the English scientists, that it has been imitated in different nations, and with the same satisfactory results. In this country such a project was both more necessary and more difficult. The scientific men were here widely distributed over a continent, and generally worked alone in the colleges, so that they very rarely met their brethren to compare notes and gain the benefits of mutual criticism. In England it was different. London was a great center of resources, a sort of scientific world of itself, while the country is so small that the metropolis is readily accessible to everybody. In the United States there was no such commanding center of scientific influence, and the distances and the expenses of travel were so great that scientific professors, generally living upon small salaries, could hardly afford to travel, even if there had been any great central headquarters to visit. The adoption of the English plan of a movable scientific association, to hold its meetings in different and widely separated localities, met the requirements of our scientific men to a much greater degree than it did the English.

This kind of association, therefore, does a more important work here than anywhere else. There are obstacles to the advance of science which are more refractory in the United States than anywhere else. Institutions for training scientific men are neither so numerous nor so thorough as in England and on the Continent. Material interests are more absorbing, and the effect of our "popular intelligence" is that subjects and questions foreign to science have an intense hold and a predominant control over the public mind. There is no way to stem these tendencies that is so adequate and practical as this annual gathering of scientific men in the different cities, and under the conditions secured by the American Association.

The problem of its success is one of social dynamics. There are resistances to be overcome in the shape of difficulties in bringing scientific men together from distant points, and of public apathy toward the interests of science. The American Association has been checked by these impediments, but it has made headway in spite of them. There has been a varying success at its different meetings, but on the whole the most encouraging progress, which is signalized by the fact that the last meeting has been the most successful and satisfactory of all.

We print the able and interesting address of the retiring President, Dr. George F. Barker. It is a model discourse of its class, reporting the present state of knowledge upon a subject of grave interest, and in a style suited to all readers of general intelligence.

Dr. Lewis H. Morgan, of Rochester, presided with an easy dignity over the general sessions of the meeting, and he could not fail to be gratified with the increasing interest shown in the ethnological studies to which he has so long devoted himself, and of which he is now the most eminent American representative. The section dealing with these subjects had many instructive papers and a full attendance throughout the meeting.

Professor George J. Brush, of New Haven, was elected the next President, and will preside over the meeting to be held at Cincinnati, beginning August 17, 1881.

THE NEW PHOTOPHONE.

The most striking result brought out at the late meeting of the American Association had reference to the relations of sound and light, and was due to the joint labors of Mr. A. Graham Bell and Mr. Sumner Tainter, of Boston. The luminous ray, whether of sunlight or from an artificial source, was shown to be capable of transmitting articulate sounds, as the wire transmits them in the case of the telephone. The mechanical combination by which this effect is produced is called the *photophone.* We print in full Mr. Bell's paper describing the principle and mechanism of the contrivance, and the experiments by which it was elucidated and brought into shape. The metal selenium, discovered in the early part of the century, but hitherto of no practical use, here comes into prominence. It was known to have curious properties, shifting into allotropic forms with the most contrasted characters, and changing its electrical relations in a remarkable manner under the influence of light. Under the arrangements of the inventors, rays of light give rise to sound by impinging upon a surface of selenium—sounds which are audible through the telephone either as continuous musical notes of different pitches, or as vocal communications. Though it is said that light produces the effect, yet this is not strictly true; for a thick plate of India-rubber, if interposed in the path of the acting beam, intercepts all the light but still permits the passage of the radiant force which produces the sound. It is some dark ray accompanying the light proper that does the work. The experimenters have found also that other substances share with selenium the property here made available, though in a less degree. We thus have another step in the rapid progress of molecular physics and the marvelous interaction of forces which is sure to stimulate experimental inquiry, though whether it will confound past conclusions and clear up past mysteries it is impossible to say. And equally impossible is it to say whether the photophone will turn out to be of any practical use. But it is certainly unsafe to deny it. The telephone is but a thing of yesterday, and was at first supposed to be only a curious plaything. But already "there's millions in it." How far it is developed as a business is shown by the fact that a convention of twenty-one companies meets at Niagara to look after the interests of this new and rapidly extending means of intercommunication.

LITERARY NOTICES.

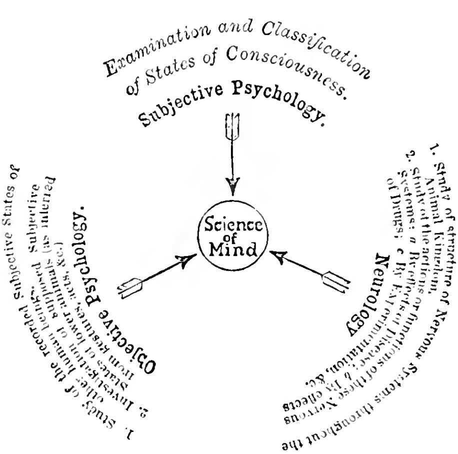
The Brain as an Organ of Mind. By H. Charlton Bastian, M. D., F. R. S. D. Appleton & Co. Pp. 708. Price, $2.50.

Dr. Bastian's new book is one of great value and importance. The knowledge it gives is universal in its claims, and of moment to everybody. It should be forthwith introduced as a manual into all colleges, high schools, and normal schools in the country. Not to be made a matter of ordinary mechanical recitations, but that its subject may arrest attention and rouse interest, and be lodged in the minds of students in connection with observations and experiments that will give reality to the knowledge acquired.

As often illustrated in the pages of this magazine, we know nothing of mind except as an organic manifestation. Throughout the entire scale of animate nature, intelligence is an endowment of a nervous mechanism; and the gradations of intelligence correspond to and depend upon gradations in the structure of the nervous system. The laws of mind have their basis in this material substratum, and mental operations are conditioned upon physiological processes. The wonderful apparatus of sensation, distributed over the periphery of the body and relating the individual to all that is outward, and the still more wonderful organ of consciousness and mental power—the great cerebral center—are material structures, and the psychical effects which they produce are accompaniments of material molecular change. We think, and feel, and remember, and imagine, and carry on all the processes of reasoning through the corporeal activities of the brain as the great center of nervous operations. We are born high or low in the intellectual grade according to the properties of this mechanism; and these properties are variable in an almost infinite degree. We get the benefit of a perfected stock through generations of cultivation, or we inherit incapacity through generations of neglect, the results in both cases being embodied in the nervous organism. It is therefore impossible to get at the science of mind so as to grasp the laws of mental growth, or rationally to carry on the work of mental cultivation without a knowledge of the vital mechanism by which all mind is displayed. No book, therefore, can be fitter for collegiate study or as a guide in the work of education than a well-prepared treatise on the physiological basis of intelligence. There are many valuable publications upon this subject, but we have seen none among them that promises to be so satisfactory as a text-book as Dr. Bastian's work on "The Brain as an Organ of Mind."

We have often discussed this subject, but its great importance, and the disposition to ignore it, nay, the actual dread of it on the part of many well-meaning people, make it necessary that there should be no relaxation in the efforts to diffuse correct ideas concerning it. For thousands of years the mind has been regarded as an entity belonging to an immaterial sphere, in some mysterious way brought into relation with the material order, but still so separated from it, and so far above it, that mental problems must be studied alone, and only by their own peculiar methods. This is the metaphysical point of view which was universally pursued before science arose, and is still the prevailing method of regarding mental phenomena. But it is a partial method, dealing only with one side of the subject, and lacking the foundation that is necessary to give scientific clearness and validity to the study of mind. Modern science has given a new extension to mental studies, but it has at the same time greatly complicated them, and introduced a factor requiring laborious and progressive elucidation; and the consequence is, that many prefer the older and easier method, regardless of the character of the results. Multitudes also shrink with a kind of horror from the association of anything material with so pure and spiritual a study as that of mind. Said an eminent spiritual-minded teacher to the writer, "I hate that word 'organization' worse than any other in the language." It is needless to say that this attitude of mind is as far as possible from scientific, and has not truth for its object. Yet the prejudice is powerful, both in paralyzing the minds of individuals and in hindering educational improvement. All the colleges and high schools in the country make loud professions of the thoroughness of their work, and they are every one occupied in dealing with the human brain; but, if there has ever been a book on the brain introduced into one of them for systematic study, we have never heard of it, and we have not been unheedful of the subject. Years are given to the most unspeakable rubbish—to subjects of study so vacant of all use that their continuance is becoming an open scandal; while a knowledge of the laws of the great organ of thought, that "institution of God" which gives law to the mental world, is passed by as unworthy of any serious attention. If the graduates from our colleges, normal schools, academies, and high schools, as they come forth, diploma in hand, were questioned as to the structure, powers, and organic relations of the brain they profess to have been cultivating, would it not be found that their ignorance is quite as great as that of those who have never had the advantage of a higher education? The subject has been too long and too grossly neglected, and we are glad of the appearance of Dr. Bastian's book, as it will take away all excuse for further neglect on the score that there is no suitable manual of the subject adapted to general use.

We can give no detailed account of this work within the limits of a notice, and only desire to convey a general idea of its method of treating the subject. There are three modes of arriving at a knowledge of the laws of mind: In the first place, each man has a source of this knowledge within himself. He carries on the mental operations in his own consciousness, and can observe and analyze them there according to his practice and skill in introspection. This source of acquaintance with mental operations is immediate and direct, and of the highest authority for the individual; but it is incomplete and liable greatly to mislead from this cause. This is known as the subjective field of inquiry. But it is possible to know something about the minds of other people in a different way. We know by experience that mind has its outward expressions, and these expressions in others, which are of the most varied kind, become indications to us of their mental states. In the same manner we acquire a knowledge of the mental activities and capacities of the lower animals, which manifest in various degrees the endowment of intelligence. What we observe without, in this way, constitutes the sphere of objective psychology. But there is another capital source of a knowledge of mind, which comes from investigating the organic structures and functions by which it is manifested in all its grades and forms. We here study the brain and nervous system, tracing its evolution from the lowest germ to the highest development, and tracing the growth of the brain of man from its embryonic rudiments to the mature and perfected structure. This branch of the study of the mind is marked off from the others by applying to it the term neurology. The following diagram, from Dr. Bastian's chapter entitled "The Scope of Mind," is designed to show how all these departments of study require to be combined in order to produce a true science of mind:



Our author does not attempt in this volume to give us a complete exposition of mental science. He has, indeed, to deal with subjective psychology and with objective psychology, but he treats these aspects of mental study in relation to the third great mental division, the organic conditions which are the latest results of scientific investigation. From this point of view, the whole subject assumes a new interest, and becomes far more practical than by the previous partial modes of examination. Dr. Bastian has done all that it was possible to do to bring his topic within the range of popular apprehension. Much of his volume will be read with pleasure and profit by all classes; but much of it also requires study and a mastery of its indispensable technicalities. The work can not be put to its proper and highest use unless the objects of which it treats are to a certain extent made real to the mind of the student. Diagrams, of which there are a great profusion, and finely executed, are helps, but they can not be put in the place of the objects they represent without a sacrifice of the first condition of true scientific knowledge—the bringing of the mind into contact with the real things. But there is happily no serious impediment to this manner of study. The brains and nervous parts of animals are to be had anywhere in abundance and in great variety. It is by no means expected that the reader or student will be able to verify the whole course of illustration in this volume, nor is it at all necessary. But it is necessary that he should become acquainted with the rudiments of the exposition by direct observation, so that he will have clear and precise ideas in relation to its subject matter, such as will conduce to a genuine understanding of the general subject. We commend this work especially to teachers, and venture to affirm that if they will form classes in it, not with a view to the slavish acquisition of its contents, but to master portions of it so that the rest may be read intelligently, it will prove invaluable both as a means and an end of education.

Dr. Bastian's book was written as a contribution to the "International Scientific Series"; but, as the author found it impossible to do justice to the subject within the limits prescribed for those works, his volume has been separately issued in this country.

Degeneration: A Chapter in Darwinism. By Professor E. Ray Lankester, F. R. S. London: Macmillan & Co. 1880. Pp. 75. Price, 75 cents.

Natural selection may have operated to produce present organic forms in three different ways. Organisms may have been elaborated in structure with a growth in variety and complexity of the conditions to which they were subjected; they may have remained for a long period without any change, when the conditions have been immobile; or, the conditions having become simpler, they may have lost in structure. In accounting for present forms, naturalists have given little heed to the last of these processes, but have endeavored to explain nearly all cases (except those of the parasites, which are generally recognized as degenerate forms) on the basis of the first two processes. In the discourse before the British Association, which forms this volume, Professor Lankester takes issue with this view, and argues in support of the thesis that degeneration is an important process in organic evolution. He contends that many problems are helped to a solution by this hypothesis, which without it are hopelessly obscure, and that the evidence in its favor is of a high order. His argument is based upon the evidence furnished by the changes through which the egg passes in its development into the young creature. As is well known, the forms through which it passes are those that belonged to its ancestors, and these are reached in the order, there is good reason to believe, in which they were acquired by these ancestors. This "recapitulative development" is often very imperfect, many characteristics are obscured or obliterated, but none appear that did not at some time belong to the creature's progenitors. Where these changes are distinct, then, the pedigree of an organism can be traced by them with certainty. A number of cases of degeneration are cited by Professor Lankester, the two most important being the ship's barnacle and the ascidian phallusia. In the case of the barnacle, the egg gives rise to an actively swimming nauplius, which after a time fastens its head to a piece of wood and adopts an immobile life. It then loses its organs of touch and sight and power of locomotion, its legs being used simply to bring any floating particles of food to its mouth. A more remarkable case of loss of structure is that of the ascidian phallusia, one of a class of sea-animals found incrusting rocks, etc., on the sea-bottom, the individuals being often joined together, forming a plant-like mass. The individual is a tough, leathery mass, shaped somewhat like a bottle, with an opening at each end, through which water continually passes, and possessed of little internal structure. Most of the young of ascidians differ widely from their parents, that of the phallusia the most markedly. The egg of this gives rise to a tadpole which bears a close resemblance in outward form and internal structure to the tadpole of the common frog, both possessing the four distinctive structures of the vertebrata. But, while the tadpole of the frog ascends in the scale of organization, that of the ascidian descends to a form in which its origin is unrecognizable. Without the recapitulative development in this case of the ascidian, Professor Lankester avers that no naturalist would have suspected that it belonged to the vertebrata, and, as this recapitulation is so frequently wanting, and when it exists is often shorn of its "most important part," it is not safe to set limits to the possible occurrence of degeneration. Many forms now supposed to be improvements upon their ancestors may, upon further investigation, be shown to be degenerate. The conditions that he thinks predispose to degeneration are parasitism, fixity or immobility, vegetative nutrition, and excessive reduction of size; and when, therefore, organisms are characterized by these habits or peculiarities, degeneration may be suspected. While Professor Lankester's discussion is confined to zoölogy, he recognizes the bearing of the hypothesis upon evolution in general—upon man and the arts perfected by him. The general conclusion he reaches is, that while the former universal belief that man and other creatures had degenerated from a previous perfect condition is untrue, the contrary opinion, that development has been a continuous progress from lower forms, is also untrue. The truth lies between the two; there have been both progress and retrogression, and both movements will probably take place in the future as in the past. The constant cultivation of those things that make for progress will alone secure any race from the possibility of degeneration. Full illustrations accompany the text to afford a ready comparison of the forms pointed out. Notes on the relation of the doctrine of development to the theological doctrine of a soul, and on some further cases of degeneration, are appended to the text.

The Obelisk and Freemasonry, according to the Discoveries of Belzoni and Commander Gorringe. By John A. Weisse, M. D. With Illustrations and with the Hieroglyphics of the American and English Obelisks, and Translations into English, by Dr. S. Birch. New York: J. W. Bouton, 706 Broadway. 1880. Pp. 178. Price, $2.00.

The newspapers last spring reported that stones bearing masonic emblems had been discovered in the foundations of the Egyptian obelisk that has since been brought to this city. A description of the emblems by Grand-Master Zola, of the Grand Lodge of Egypt, and a letter from Consul Farman, at Alexandria, confirming the fact that discoveries had been made, were also published. Dr. Weisse, who fully believes in the antiquity of masonry, was presented by Mrs. Belzoni, widow of the celebrated Egyptian traveler, in 1850, with manuscripts, drawings, etc., assuming to show that an institution similar to freemasonry existed in Egypt before pyramids and obelisks. All of these evidences, with other matter and illustrations bearing upon the same point, have been combined in this work, which is curious and interesting if not historical and scientific.

Annual Report upon the Surveys of Northern and Northwestern Lakes and the Mississippi River, in Charge of C. B. Comstock, Major of Engineers, etc.; being Appendix MM of the Annual Report of the Chief of Engineers for 1879. Washington: Government Printing-Office. Pp. 80.

The report shows progress in the triangulation of Lake Erie, the triangulation connecting Lake Erie with Lake Michigan, the erection of stations for the triangulation running south from Chicago, and water-level observations on the lakes. Progress has also been made on the survey of the Mississippi River. The longitudes and latitudes of Louisiana, Missouri, Rock Island, Illinois, and Red Wing, Minnesota, have been determined. Several of the coast-charts of Lakes Ontario and Erie, and charts of the Mississippi south of Memphis, have been completed. Among the important facts noticed is the observation of sand-waves in the Mississippi at Helena, which in water from thirteen to thirty feet deep are moving down the river at an average rate of eighteen feet a day. They had an average length, counting from crest to crest, of about three hundred and thirty feet, an extreme length of about five hundred feet, and an average height of about five feet and an extreme height of eight feet from valley to crest. The existence of sand-waves of so large dimensions, and moving with such a velocity, does not seem to have been observed before on the lower Mississippi.

The Microscopist's Annual for 1879, No. 1. New York: The Industrial Publication Company. 1880. Pp. 48. Price, 25 cents.

The object of this publication is to keep microscopists informed of what is going on that is of particular interest to them. It contains a list of microscopical societies in the United States and of a few foreign societies, and the names, alphabetically arranged, of manufacturers and dealers in microscopes, objects, apparatus, etc., in the United States and Europe, with other practical information.

The North American Entomologist. July, 1879, to April, 1880. A. R. Grote, Editor. Buffalo, N. Y.: Reinecke, Zesch & Baltz. Monthly. Pp. 8. Price, $2.00 a year.

This magazine was begun with the purpose of presenting original articles of value both to the specialist and the agriculturist on the subject of North American insects and notices of current entomological literature. The articles in the ten numbers before us show the results of careful research, present new facts, and are many of them well illustrated.

Heveenoid: The Rubber of the Future. By Henry A. Mott, Jr., Ph. D., etc. New York: Trow's Printing Company. Pp. 13.

Heveenoid is India-rubber combined with camphor and vulcanized by sulphur. It was invented by Henry Gerner, and is offered as a new product to supplant the common soft and hard vulcanized India-rubber, over which it is claimed to possess many points of superiority. These points are set forth, and the process of manufacture is described, in the pamphlet.

The Oriental and Biblical Journal. Edited by Rev. Stephen D. Peet. Chicago: Jameson & Morse. 1880. Pp. 52. Quarterly. Price, $2.50 a year.

The object of this magazine is to give the results of the latest researches in all the Oriental lands and in the countries of classical history. It is intended also to embrace many subjects of a more general character, such as the manners and customs of all nations, their traditions, mythologies, religious notions, language, and literature. In the present number, Professor T. O. Paine describes two Osirids of ancient Egypt owned by persons in the United States; and, in an article on "The Antiquity of Sacred Writings in the Valley of the Euphrates," Mr. O. D. Miller seeks to prove that the materials of the Book of Genesis were derived through Abraham from the same originals whence the oldest Chaldean writings came.

The Thousand Islands of the River St. Lawrence; with Descriptions of their Scenery, as given by Travelers from Different Countries, at Various Periods, and Historical Notices of Events with which they are associated. Edited by Franklyn B. Hough. Syracuse, N. Y.: Davis, Bardeen & Co. 1879. Pp. 307. Price, $1.25.

The title gives as clear an idea of the character of this book as can be gained from a fuller description. The historical sketch is ample and satisfactory. The travelers' descriptions date from Charlevoix, in 1721, are favorable and unfavorable, and are quoted from a host of authors of various nationalities. They are followed by a chapter on the poetical associations, and by notices of the camp-meeting parks, geology, names, and other features of the islands.

Diagram of the Progress of the Anthracite Coal-Trade of Pennsylvania, with Statistical Tables, etc. By the Messrs. Sheafer, Engineers of Mines, Pottsville, Pa. Chart.

This diagram is designed to accompany a paper which was read before the American Association for the Advancement of Science, at its meeting for 1879. It shows the gradual development of the trade, and the dates of the opening of new avenues to the market. An accompanying diagram shows the estimated quantity of anthracite coal in the three several coal-fields of Pennsylvania, and the relative amount of waste and quantity mined. Another cut represents a cross-section in the southern anthracite coal-field of Pennsylvania. The tables show a variety of facts bearing on the subject, in Pennsylvania, the United States, and the world.

American Health Primers.—The Summer and its Diseases. By James C. Wilson, M. D.—Winter and its Dangers. By Hamilton Osgood, M. D. — The Throat and the Voice. By J. Solis Cohen, M. D.—Brain-work and Overwork. By Dr. H. C. Wood. Philadelphia: Presley Blakiston. 1879 and 1880. Pp. 126 to 160. Price, 50 cents each.

These primers are prepared for the purpose of diffusing as widely and cheaply as possible a knowledge of the elementary facts of preventive medicine and the bearings and applications of the latest and best researches in medical and hygienic science, and of teaching people how to take care of themselves, their children, etc. They are written from an American point of view, with especial reference to our climate, sanitary legislation, and modes of life. The whole series is under the general supervision of Dr. W. W. Keen. The first volume, whose title is given above, considers each of the common special diseases of summer, and the means of preventing and curing them, and has a chapter on the skin in summer and its maladies. The second work enforces the need of suitable clothing, care in bathing, ample provision of pure fresh air, and out-of-door exercise in winter. In the third volume, the structure, care, and several diseases of the throat are treated of in separate chapters, and a second part is devoted to the voice and its cultivation. In the last primer of the list are discussed the subjects of the "Causes of Nervous Trouble," "Work," "Rest in Labor," "Rest in Recreation" and "Rest in Sleep."

Memoirs of the Science Department, University of Tokio, Japan. Vol. II. On Mining and Mines in Japan. By C. Netto, M. E., Professor of Mining and Metallurgy, University of Tokio. Published by the University, Tokio. 2539 (1879). Pp. 56, with Plates.

This work comprises the substance of a lecture which was delivered before a German society, and has been translated into English to make it more accessible to Japanese students. The useful minerals in Japan, ranked nearly according to their importance, are coal, copper, silver, gold, iron, kaolin, petroleum, sulphur, lead, antimony, tin, cobalt, quicksilver, marble, jasper, agate, amber, graphite. The processes of mining and reducing the ores are described, after which is given a summary of the Japanese mining law, and a review of the measures that have been adopted or are contemplated by the Government for the encouragement of mining. Modern methods are shown to have been adopted in several of the mines, and their introduction has been attended with increase of production. The Government at present carries on a number of mines, into which it has introduced modern model works, partly for the sake of setting a good example to private owners. It is its policy, however, to surrender its establishments when they have become well organized, to be worked by private citizens. Six large plates give representations of the tools used by the Japanese in mining.

The American Journal of Philology. Edited by Basil Gildersleeve, Professor of Greek in Johns Hopkins University. Vol. I., No. 2. May, 1880. Baltimore: the Editor. New York and London: Macmillan & Co. Pp. 126. Four numbers a year. Subscription price, $3.00.

This journal is open to original contributions in all departments of philology, gives condensed reports of current philological work, summaries of the chief articles in the principal philological journals of Europe, and keeps watch over the fragmentary and occasional literature to which the isolated American scholar seldom has full access. The present number has an article on "Recent Investigations of Grimm's Law," by H. C. G. Brandt; three articles on Greek and Latin subjects, by F. D. Allen, C. D. Morris, and M. W. Humphreys; and two on French subjects, by B. F. O'Connor and Samuel Garner.

First Annual Report of the Department of Statistics and Geology of the State of Indiana, 1879, to the Governor. Indianapolis: Douglass & Carlon. Pp. 515.

This report embraces ninety-nine tables of agricultural, mercantile, manufacturing, financial, and other statistics, by counties and townships. The report of the Indiana State Health Commission, which is embodied with the general report, embraces papers on "Health in the Schoolroom," by President Moss, of the State University; "Topography and Climate," by Professor Campbell, of Wabash College; "Decomposing Organic Matter, Sewage, and Drainage," by Dr. G. W. Burton; "The Influence of Popular Customs, Habits, and Heredity, on Public Health and Morals," by Dr. J. W. Hervey; and "The Influence of Geology upon Local Diseases," by E. T. Cox, late State Geologist.

Macmillan & Co. have in press, for publication in the early fall, a book which is likely to be of value to the medical profession, and of advantage to the general public; it is entitled "Food for Invalids," and is written by Dr. J. Milner Fothergill, of London, and Dr. H. C. Wood, of Philadelphia.

Henry George's "Progress and Poverty" has been translated into German by F. Gutschon, and will be shortly published by Stude, of Berlin.

PUBLICATIONS RECEIVED.

Report to the Trustees of the "James Lick Trust" of Observations made on Mount Hamilton, with reference to the Location of Lick Observatory. By S. W. Burnham. Illustrated. Chicago: Knight & Leonard. 1880. Pp. 32.

Quarterly Report of the Chief of the Bureau of Statistics relative to Imports and Exports, Immigration, and Navigation of the United States, for the Three Months ending March 31, 1880. Washington: Government Printing-Office. 1880. Pp. 190.

Adirondack Survey: Report on Iron Deposits, etc. By George Chahoon. Albany: Weed, Parsons & Co. 1880. Pp. 16.

Electricity: Elementary Guide-Book for Practical Experiments and Self-Study. By Professor Curt W. Meyer. With Illustrations. New York. 1880. Pp. 25. 25 cents.

The Claims of Science, for its own Sake, upon the Medical Profession. Address, by Professor John W. Mallet, M. D., of the University of Virginia. Baltimore: J. W. Borst & Co. 1880. Pp. 28.

Medical Science in Conflict with Materialism. By Eugene Grissom, M. D., LL. D. Wilmington, N. C.: Jackson & Bell. 1880. Pp. 31.

Notes on the Flowering of Saxifraga Sarmentosa. By Professor J. E. Todd. Reprint from "American Naturalist." Illustrated. Pp. 6.

Ophthalmic Operations, with Remarks on After-Treatment. By A. Sibley Campbell, M. D. Augusta, Ga. Pp. 35.

The Laterite of the Indian Peninsula. By W. J. McGee. Reprint from "The Geological Magazine." Pp. 4.

Annual Report of the Board of Directors of the Chicago Astronomical Society, with Report of the Director of the Dearborn Observatory. Illustrated. Chicago: Knight & Leonard. 1880. Pp. 16.

Review of Stratigraphical Geology of Eastern Ohio. By Professor Edward Orton. Columbus: Nevins & Myers. 1880. Pp. 33.

American Natural Cement. By F. O. Norton. Illustrated. Pp. 18.

Circulars of Information of the Bureau of Education. No. 2. 1880. Washington: Government Printing-Office. 1880. Pp. 111.

Introduction to the Study of Mortuary Customs among the North American Indians. By Dr. H. C. Yarrow. Washington: Government Printing-Office. 1880. Pp. 114.

What to do First in Accidents or Poisoning. By Charles W. Dulles, M. D. Illustrated. Philadelphia: Presley Blakiston. 1880. Pp. 70. 50 cents.

The Skin in Health and Disease. By L. Duncan Bulkley, M. D. Philadelphia: Presley Blakiston. 1880. Pp. 148. 50 cents.

Manual of Hydraulic Mining for the Use of the Practical Miner. By T. F. Van Wagener, E. M. New York: D. Van Nostrand. 1880. Pp. 93.

The Authorship of the Fourth Gospel: External Evidences. By Ezra Abbott, D. D., LL. D. Boston: George H. Ellis. 1880. Pp. 104. 75 cents.

Qualitative Chemical Analysis: a Guide in the Practical Study of Chemistry and in the Work of Analysis. By Silas H. Douglas, M. A., M. D., and Albert B. Prescott, M. D., F. C. S. With a Study of Oxidation and Reduction by Otis Coe Johnson, M. A. New York: D. Van Nostrand. 1880. Pp. 305.

Deep-Sea Sounding and Dredging: a Description and Discussion of the Methods and Appliances used on Board the Coast and Geodetic Survey Steamer "Blake." By Charles D. Sigsbee, Lieutenant Commander, U. S. N. Illustrated. Washington: Government Printing-Office. 1880. Pp. 200.

POPULAR MISCELLANY.

The Cotton-Worm Investigation.—The Commission for the investigation of the cotton-worm has been organized under Professor C. V. Riley as chief, and its members have been stationed at different points in the South to make local examinations. Professor J. P. Stillé, of Alabama, and Judge J. W. Jones, will represent the Commission in Texas; Professor R. W. Jones, Dr. E. H. Anderson, and Mr. Lawrence Johnson, in Mississippi; Mr. H. G. Hubbard, of Detroit, Michigan, in Florida; Professor Barnard, of Cornell University, will fully study those parts of Louisiana and Mississippi which were neglected in 1878 and 1879 on account of yellow fever; Judge J. F. Bailey, and Mr. James Roane, chemist, will make a special series of experiments in Alabama; Professor J. E. Willet will make experiments in Georgia to test the usefulness of fungus-germs in the destruction of the worm. Maps are to be prepared by Professor Smith, of the State University of Alabama, showing the different cotton regions classified with reference to the hibernation of the insect. Professor Riley, besides having the general superintendence of the work, and advising with his assistants, will collect information and make other preparations for introducing the cultivation of the *pyrethrum*, which he believes will afford a safe antidote for the worm.

Changes in the Natural Vegetation at San Francisco.—Dr. Herman Behr has published a description of the changes that have taken place in the vegetation of the San Francisco peninsula within the last thirty years. The region was originally distinguished by three types of landscape: the sand-dunes and hills, covered with live-oak, ceanothus, horse-chestnut, and wild cherry, ferns, and common herbs; an open tract of grassy plains, with trees in the ravines, and flowering plants; and a marshy plain, with boggy prairie, covered with a varied growth of bushes and herbaceous plants. Now, the first-mentioned type of vegetation, the *chaparral*, exists still in a few spots; the second, that of the pasture-land, is to be met with still, wherever the distance from the city is considerable enough to protect native vegetation; but the third type has entirely disappeared. In the course of the extension of the city, Australian evergreens and conifers form the Sierra have largely replaced the original trees. "Parallel with this artificial immigration of Australian arborescents, goes on an herbaceous immigration from Europe and Africa." The thistle (*Silybum marianum* of the Mediterranean region) has invaded both California and South Australia, and, wherever it gets a hold of the soil, all native vegetation disappears. The tree-lupines particularly suffer from its encroachment. Another weed, *Cotula coronopifolia*, a native of South Africa, well known in Mediterranean Europe, and which has invaded South Australia, does the same work in moist ground that is begun by silybum in more arid tracts. It "has transformed the varied aquatic vegetation of the different places infested by itself into one monotonous green mass with yellow buttons." Dr. Behr regards as significant that these two plants are congenital and belong to one of the most modern orders, of which fossil specimens are found in only the most recent formations, and to which he attributes the vigor of youth.

The Physiological Effects of Tea and Coffee.—Professor Albert B. Prescott, M. D., of the University of Michigan, has published a paper, in "The Physician and Surgeon," on the physiological effects of coffee as compared with those of tea, concerning which the authorities are confusing and little is really known. Inasmuch as the chief constituents of both substances are capable of determination, we ought to be able to declare something, he thinks, as to what there is in common between a medium cup of coffee and an average cup of tea. The effects of tea and coffee, he continues, must be mainly due to the properties and proportions of the alkaloids, tannin, volatile oils, and ordinary food-substances contained in them. As to the alkaloids, no differences have been established between theine and caffeine. In average quantity, the alkaloid forms about one per cent. of the raw coffee-berry, and two or three per cent. of tea. A little of it, but very little, is lost in roasting coffee. The greater part of it is extracted in the beverage as usually prepared, both of tea and coffee. A pound of tea usually furnishes from three to five times as many pints of beverage as are obtained from a pound of coffee, but the ways of preparing and the estimates are so different that nothing exact can be determined on this point. As a whole, the proportions for given volumes of beverage can not be declared habitually much larger in the one than in the other; if there is any difference, the coffee-beverage is likely to be the stronger. The tannins are tannic acid in both substances—boheic and gallic acid in tea, and caffeic acid in coffee, all astringents. Tea contains, according to the analyses relied upon by Dr. Prescott, from six to twenty per cent., an average of twelve per cent. of tannins; some other estimates make the percentage very much larger. This large amount is, however, by no means all dissolved in the ordinary preparation of tea as a beverage. No tannin was dissolved in steeping for five minutes six out of eleven specimens of different qualities of tea at the Michigan University, and the percentage of the other five specimens was not large, the average percentage of the whole being only 0·08. After thirty minutes' steeping, the quantity of tannin dissolved varied from 1·09 to 4·50 per cent., the average being 2·49, and was in no case equal to half the amount contained in the tea. A larger quantity of tannin was extracted in other experiments in which the tea had been macerated at ordinary temperature before boiling. The tannin in coffee-berry, by all reports, is not more than one third the quantity of that in tea-leaves, and may be considerably less. Six specimens of coffee were steeped for five minutes without yielding any tannin; two of them showed a trace of tannin after ten minutes' steeping; after twenty minutes', five of the specimens showed from 0·01 to 0·25; after thirty minutes', the proportion of tannin given up varied from 0·09 to 1·80, the average being 0·83. Other analyses show that tea contains an average of 0·206 grains, coffee 0·055 grains, of tannin to the fluid ounce of the beverage in use. These results leave no doubt that the tea we drink contains at least four or five times as much tannin as the coffee we drink, and that the tea yields only a small proportion of its large quantity of tannin, after from five to ten minutes of steeping. If tea or coffee is to be administered, as in any case of poisoning by alkaloids, tea, well steeped, is to be chosen as the better antidote for the precipitation of alkaloids, and equally potent as a stimulant. The essential oil of tea is a very small but distinct constituent, the most important factor in determining its market value. It is conjectured to be an organic stimulant, and may promote perspiration. Coffee, in the unroasted berry, has no volatile oil; but, in roasting, an agreeable essential oil is developed, the effects of which are not known, but which may cause the digestive disturbance sometimes ascribed to coffee-drinking. Of nutrient substances, tea contains pectin, gum, legumine, and indeterminate matters, yielding, in all, to boiling water about thirty-two per cent. of its weight. Coffee contains, after roasting, from one to two per cent. of glucose, ten to twelve per cent. of fat, nearly as much legumine, and a little gum, and yields thirty-five per cent. to water. "It is not unlikely," Dr. Prescott concludes, "that these food-substances, as modified by roasting, disagree with the digestion of many persons. This is, let me submit, a not improbable explanation of the class of injurious effects of coffee-drinking, when the substitution of tea-drinking gives relief. The powerful nerve-stimulant, caffeine, as we have seen, is obtained in about as large doses from tea as from coffee. The caffeine of both these beverages undoubtedly produces injury to the nervous system in many cases; but, when coffee causes palpitation, sleeplessness, etc., not resulting from tea, let me suggest that some attention be paid to the digestive organs."

Water in Disease.—Dr. S. G. Webber, in the "Archives of Medicine" for August, attributes a considerable value to water as a preventive and a remedy of disease, and opposes the abstinence from drinking at meals, advocated by many, as injurious. Among patients who have come under Dr. Webber's care affected with "symptoms of an undefined character, a vague unrest and disquiet showing itself by discomfort or even pain, sometimes in one place, sometimes in another," with constipation and an unhealthy hue of the skin, he has found that many were accustomed to take less than the usual average quantity of drink. In such cases he would prescribe an increased quantity of drink, with beneficial effects in increased perspiration, and the decrease or disappearance of the unpleasant symptoms. The waste of tissue-changes in the system passes into the blood, and leaves the system only in solution. This, Dr. Webber maintains, can not take place unless enough water is taken. Further, "water taken with the food favors digestion; when taken into the stomach a part is absorbed by the gastric vessels, carrying with it the soluble constituents of the food. So much as is not immediately absorbed assists in softening and breaking up the larger particles of food, and thus aids in the gastric digestion by facilitating the action of the gastric fluids." It also makes it easier to keep the bowels regular. In estimating the quantity of water to be taken daily, we should remember that water is excreted by the lungs and skin, as well as by the kidneys, and that much food contains water. Hence the amount required must vary slightly with the activity of the skin and the character of the food. Dalton states that the average amount is about fifty-two ounces, or 3·38 pints, or the equivalent of eight or nine coffee-cups of drink.

Temperature of the Breath.—Mr. R. E. Dudgeon has been trying some experiments on the temperature of the breath, and infers from the results that it is considerably higher than has generally been stated, and that it is variable. First, on rising in the morning, having ascertained the temperature of his body as shown by the thermometer in the axilla and mouth to be normal—about 98½°—he wrapped the thermometer tightly in a silk handkerchief and breathed upon it. In five minutes it indicated 106·2. At 7 P. M., after a brief walking exercise, and when he had eaten nothing but a spoonful of boiled rice, and drunk only half a glass of water and a mouthful of ginger-beer, his breath raised the mercury to 107°. Immediately after a dinner at which only water was drunk, a temperature of 108° was shown. At other times the thermometer would not rise, under apparently the same conditions, higher than 102° to 105°. He can suggest no way of accounting for these indications otherwise than by admitting that they show the actual temperature of the breath as it issues from the lungs. "If so," says Mr. Dudgeon, "it is by the breath that the system gets rid of its superfluous caloric." The experiments seem to show that the temperature obtained from the breath is higher when the surrounding air is warm than when it is cold, indicating possibly that more heat is passed off by the breath when less can escape from the general surface of the body.

The Ancient Outlet of Lake Bonneville.—The name of "Lake Bonneville" has been applied to a great body of water which formerly covered the desert basins of Utah, of which the most conspicuous vestiges are its shore-lines. It is known from them that the ancient water-surface was more than ten times as great as that of the Great Salt Lake, and that the ancient level of the water was about one thousand feet above the modern level. The point at which the waters of this lake were discharged is still undetermined. Mr. G. K. Gilbert maintained, in the "American Journal of Science" for April, 1878, that the point of overflow was Red Rock Pass, Idaho, at the north end of Cache Valley; that the discharging stream descended through Marsh Valley, and thence continuously to the Pacific Ocean; and that, flowing over soft material at first, it gradually excavated at the pass a channel more than three hundred feet deep, and lowered the level of the lake by the same amount. Dr. A. C. Peale controverted Mr. Gilbert's conclusion in a subsequent number of the "Journal," and held that the original altitude of the Red Rock Pass was considerably below the highest level of Lake Bonneville; that the original shore-line exists in Marsh Valley, at the north end of the pass, as it does in Cache Valley at the south; and that the real point of discharge, when the water stood at the Bonneville level, was about forty-five miles north of Red Rock Pass. Mr. Gilbert has, within a few months, revisited Marsh Valley and Red Rock Pass, and other points near the former supposed outlet of the lake, and gives in the May number of the "Journal" his reasons, derived from his later observations, for adhering to his former conclusion. He assumes to determine the character of the body of water which has occupied a given spot, whether it was a stream or a lake, from the nature of the terraces left in the valley. Thus there are stream-terraces, and wave-terraces, and delta-terraces, and others, all marked by distinct features. A lake should leave wave-terraces or delta-terraces. In revisiting Marsh Valley, he traversed it from end to end, making a careful search for the terraces of the ancient shores, selecting the most favorable stations and lights he could get. He saw stream-terraces and displacement-terraces of considerable magnitude, and a few inconspicuous terraces due to unequal erosion, but no wave-terrace and no delta-terrace. He made a special examination of two terraces referred to by Dr. Peale in support of his views, but did not recognize in them any features inconsistent with the opinion that they are stream-terraces. He consents to reconsider his original location of the outlet of the lake at the time of the beginning of the overflow, and assigns it to a position two miles north of Red Rock, instead of at that point, and the distance nearer to the place fixed by Dr. Peale than the place where he first fixed it. Mr. Gilbert Thompson, an expert topographer, visited the northern limits of the lake in 1877, while ignorant of the results of Mr. Gilbert's examination, and came to the same conclusion that he had reached. In a letter to Mr. Gilbert, dated April 10, 1878, he says: "I was delighted, at Red Rock, to see unmistakable evidences of the ancient outlet of Great Salt Lake. . . . Thus you may have the gratification of knowing of an independent and entirely unbiased verification of your determination of this point."

A Fresh-water Medusa.—A new medusa, which lives in fresh water—the first fresh-water medusa known—has been discovered in the tank of the water-lily house of the Royal Botanical Society in London. It flourishes and multiplies rapidly in water of a temperature of about 90°, and the specimens with which the tank swarms are described as being very energetic in their movements and apparently in the conditions which contribute most completely to their well-being. The new jelly-fish has attracted great attention among naturalists, and minute descriptions of it are given by Mr. Romanes and Drs. Allman and E. Ray Lankester. Mr. Romanes has found that exposure to sea-water kills it, and that it is more intolerant of sea-water than are the marine medusæ of fresh water. Dr. Allman has named it *Limnocodium Victoria* and gives it a position between the *Leptomedusæ* and the *Trachomedusæ*, while he regards its affinity with the *Leptomedusæ* as the closer.

Origin of Chinese Civilization.—A new view of Chinese civilization has been presented by M. A. Terrien de la Couperie, who asserts that the ordinary opinion, which would regard China as a world by itself—with a distinct language, and a peculiar way of writing which it has invented for itself—is incorrect, and is based on insufficient study. The error has been committed by regarding the Chinese and their language as they are, and not studying them historically and tracing them as far back as possible. This M. Terrien de la Couperie has done, according to the testimony of Professor Robert K. Douglas, with success. Great changes were made in the language in the early centuries of the Christian era, and the present system dates from no further back than the fourth century. The more ancient language may be studied from a number of sources, of which M. Terrien specifies eleven classes. One of the most important documents is the Yh King, which is supposed to embody some of the most ancient writings in the language. Some of the texts are attributed to the times of the legendary Fuh-he, B. C. 2852, and became the subject of commentaries as early as B. C. 1150. M. Terrien is the first person in modern times who has succeeded in explaining any of it. The archaic Chinese characters were derived from hieroglyphics, and the hieroglyphics were accompanied by a certain number of phonetic signs. A study of the most ancient forms and a comparison with the other sources of information have led M. Terrien to recognize in the Chinese spoken language an ancient member of the Ural-Altaic family of agglutinant languages, in which it constitutes a new, a third division of the Amardian group, a group which also includes the Akkadian and its dialect, the Susian and Kossian languages. The vocabulary of the ancient language, as may be shown by citations of hundreds of words, connects it with the Akkadian and Susian dialects; but it has certain "very marked grammatical affinities" with the Ugro-Finnish tongues. The resemblances of the ancient Chaldean and Chinese hieroglyphics are very strong; and one point to be noticed is that, in both systems, the images are drawn full-face instead of in profile, as in Egyptian hieroglyphics. Further evidence of the connection thus suggested is given in the facts that certain parts of the Yh King are only lists of meanings that pointedly recall the Akkadian cuneiform syllabaries; that Hoang-ti, the first of the five Chinese emperors who reigned at the dawn of history, was in the ancient language Nak-kon-ti, suggesting a correspondence with the Susian god Nakhunta and King Kudur Nakhuta; and in numerous cases of at least apparent correspondence in the most ancient titles, customs, and allusions of the Chinese and the Susians. Resemblances have also been pointed out between many Western features and those of the Chinese. A part of these, M. Terrien admits, is owing to the progress of the Chinese, to communication, and later changes; but another part, he maintains, "perhaps the earliest and most important, traces its origin to the first establishment in ancient China of a part of that Akkado-Chaldean culture, to which our modern civilizations are indirectly so referable."

Curious Discovery of a Murder.—A story of a remarkable discovery of a murder comes from Bermuda. A handsome and decent mulatto woman suddenly disappeared in October, 1878, and her husband was suspected of having murdered her, but no trace of her could be found, and it seemed probable that the crime would not be detected. A week afterward, while anxiety on the subject was still at its height, some boatmen, looking out toward the sea, were struck by observing in the Long Bay Channel, the surface of which was ruffled by a slight breeze, a long streak of calm, such as a cask of oil usually diffuses around it when in the water. A connection with the disappearance of the woman was at once suggested; a search was shortly afterward made at the place for the body; the skeleton was found held down by weights, and the fragments of flesh remaining upon it were in such a condition as to show that it had not lain long in the water. Identification was established by means of portions of clothing. The man, who was a fisherman, had calculated that the fish, which were numerous in the channel, would soon destroy all means of identification of the body, but it never occurred to him that their ravages as they did so would set free the matter which was to write the traces of his crime upon the surface water. The peculiar feature of the calm seems to be a novel one, not mentioned in works on medical jurisprudence and outside the experience of doctors.

The Climate and Meteorology of Zanzibar.—Considerable interest is attached to the climate and meteorology of Zanzibar, since that island is the starting-point of most of the expeditions which proceed into the interior of East Africa. Observations taken by Dr. John Robb, of the Indian army, during the five years from 1874 to 1878, show that the average rainfall, which they give at not more than sixty-one inches, or double that of England, has very materially decreased since the time when Dr. Christie and Captain Burton made their observations; and it is suggested that the decrease may be due to the destruction of the trees over the whole island by a cyclone which swept it in 1872. The average number of rainy days is one hundred and twenty in the year. The double seasons, which are of unequal duration, are marked out by the prevailing winds, and are less exactly determined by the so-called greater and lesser rains. The rainy seasons begin when the sun crosses the zenith of Zanzibar in passing to its northern and southern declinations, March 4th and October 9th. The greater rains fall in March, April, and May, the lesser rains from the middle of October to the end of the year. The driest month is September. The mean temperature of the five years was 80·6°, the hottest months being February and March, with a mean temperature of 83·1° and 80·4° respectively, the cooler are July and August, with mean temperatures of 77·5° and 77·7°. These figures give a variation of less than 6° in a year, and to this limited range is ascribed the debilitating nature of the climate. The mean pressure of the barometer for four years differed but a thousandth of an inch from that indicated at the equator. The coast of the mainland of Africa, Dr. Robb says, is undoubtedly prejudicial to health, and both Europeans and natives of India who pass any considerable time there suffer severely from fever of a bad remittent type, and from dysentery. All seasons are bad, but some are better than others, and travelers going into the interior are usually advised to leave the coast-region before the heavy rains begin to fall. The seeds of disease are often sown by even a short residence on the coast, and the traveler dies before he has advanced many marches into the interior. Travelers, therefore, should always make a careful and quick march across the unhealthy belt of country along the coast, and pitch their camps in the higher and drier districts beyond; and, if they have to linger on the coast, they should take care to pass their nights in the safest places they can find.

Application of Cold in Industrial Chemistry.—Heat, of temperatures above the freezing-point of water, has long been known and used as one of the most powerful agents for producing the chemical operations desired by manufacturers. Heat of temperatures below the freezing-point, or cold, as it is commonly called, has been less generally employed, and enjoys less recognition as a force capable of practical application for production. It has been lately made to aid in the manufacture of Glauber's salt at some French works with such success as to suggest that its more general application is possible in other directions. Alum and copperas were formerly made from the pyretic shales of Rheims and Picardy, but the product from these sources has been driven from the market by the competition of other alums. A new process has been devised by M. Georges Fournier, of Paris, under which the lye from the oxidized shales, containing all of the aluminum sulphate and a portion of iron sulphate after a considerable part of the copperas has been deposited, is mixed with common salt in such proportion that there shall be sodium enough to combine with all the sulphuric acid, and chlorine enough to take up all the aluminum and iron. The mixed solution is then exposed to a temperature of from 3° to 5° below the freezing-point, at which the sulphate of soda is almost insoluble. That substance is deposited in the ordinary form of Glauber's salts as a fine crystalline sediment, while the aluminum and iron remain in solution as chlorides. The "mother-liquor," or lye, is then run off, and the deposit is washed in brine cooled down to the freezing-point. After it is dried, it is fit for any purpose to which Glauber's salt is applicable. The mother-liquid which has been run off may be made into a chloride of aluminum, which is valuable for disinfecting purposes. A pure chloride of aluminum, suitable for use in dyeing, and for the destruction of the vegetable matter which is mingled with wool, may be prepared from cake-alum by a similar cold process. The results of the operation are, as before, a deposit of Glauber's salt and a solution of chloride of aluminum, but the latter substance is free from the admixture of iron. Another French inventor, by exposing the lyes of the "sal mixte" of the salt-works of the Mediterranean coast, consisting of common salt and sulphate of magnesia, to a temperature of about 11° below the freezing-point, obtains Glauber's salt in deposit with a solution of the chloride of magnesium, a substance largely used for weighting textile fabrics.

Fertility of Hybrids.—Mr. Darwin, in his "Origin of Species," has mentioned a case on the authority of Mr. Eyton, in which hybrids from the common goose and the Chinese goose were as fertile as among themselves. He has now reported in "Nature" concerning his success in raising birds from the eggs of a brother and sister from the same hatch of hybrids of these two species. Two trials were made: three birds were hatched from the first set of eggs, two others were fully formed but did not succeed in breaking through the shell, and the remaining eggs were unfertilized. From the second lot of eggs two birds were hatched. The hybrids, grandchildren of the pure parents, were extremely fine birds, and resembled their hybrid parents in every detail. Mr. Darwin's success was not equal to that of Mr. Eyton, who reared eight hybrids from one set of eggs; and he attributes the difference in part to the close confinement in which the hybrid parents were kept and their close relationship. Another illustration of the possible fertility of hybrids to which attention has been directed, is given in Mr. J. A. Allen's "History of the American Bison," where it is said that that animal interbreeds freely with the domestic cow, and that the half-breeds are fertile.

The Highest Mountains of the Earth.—Hermann von Sclagintweit Sakünlinski, in the last volume of his journeys in India and high Asia, gives a table of altitudes, including statements of the heights of the most elevated mountains. The elevations are not extraordinary south of the Himalayas, the most marked ones being four mountains from 11,000 to 15,300 feet high in Assam, and the Sufed Koh peak in the Punjaub, 19,839 feet high. The eastern Himalayan district, embracing Bhootan, Sikkim, and Nepaul, contains the highest mountain known on the earth, which is called Mount Everest by the British, Gaurisankar by the people there, and is 29,002 feet high; and the third highest, Kintchinjunga, 28,156 feet high, and has besides thirty-two mountains of more than 20,000 feet, and thirty-two of more than 10,000 feet. The western Himalaya region, extending from Kumaon to Hazasa, exhibits the Nanda Devi in Kumaon, 25,749 feet, as its highest peak, and has besides twenty-nine mountains of more than 20,000 and 108 of more than 10,000 feet in height. In eastern Thibet are ten Alpine stations between Lassa and Guari Khorsum, more than 10,000 feet high, two of them reaching to 15,500 and 16,700 feet, and Lassa, the capital, is 11,700 feet high. Western Thibet, from Guari Khorsum to Balti, ranks next after the eastern Himalayan region in its elevations, having within its boundaries the second highest mountain known on the earth, the Dapsaug, 28,278 feet high, with twelve mountains of more than 20,000 and seventy-three of more than 10,000 feet in height. The highest point in eastern Turkistan is the summit of the Kwen-lun, 20,000 feet high. The great passes of the world are in this territory. They include the Kizilkorum pass in Yarkand, at an elevation of 17,762 feet, the Kilian pass in Khotan, 17,200 feet, and the Elchi-Davan pass in the Kwen-lun Mountains. The snow-line appears at a height of 15,100 feet on the north side of the Kwen-lun, of 15,800 feet on the south side, of 18,665 feet on the western slopes of the Guari Khorsum, and 18,010 on the northern slopes; and phanerogamous plants reach up to 19,237 feet on the western side. The highest places inhabited by man are in Thibet at a height of between 14,800 and 15,000 feet, but above these are the Hanli Cloister, 15,117 feet, and the Thok Jalang gold-field, 16,330 feet. In all, these mountain regions contain seventy-three peaks more than 20,000 feet high, of which seventeen rise above 25,000 feet. Dhawalagiri, in Nepaul, 26,680 feet high, which was formerly considered the highest mountain on the earth, is remanded to the fifth place, being exceeded, besides the three already named as the three highest, by the Sisbut peak, in Nepaul, 27,799 feet.

Butter-making in Denmark and Sweden.—Some of the best butter in Europe is made in Denmark and Sweden, and commands a price in the London market 23 per cent. higher than the best Cork butter. Canon Bagot, who has taken pains to investigate this subject, ascribes this superiority to the education of the dairy-maids, which has been systematically pursued in Denmark since 1864 and 1865. In Sweden the dairy-maids are sent to a college and educated in dairy management for six months, at the end of which time they receive certificates and are considered competent to work in large dairies. Their instructions are very definite as to every feature of the operation of butter-making, including the quality of the salt and the coloring matter, and the food of the cattle; the quality of the butter is consequently uniform. A part of a lot of Cork butter may sometimes be sent back by the wholesale dealer because it is not equal to the rest, but this is said never to happen with Danish butter. The selection of the cows and the feeding of them are the first important points in the business. The Danish dairymen keep their cows tethered during the summer in "splendid clover and rye grass," and feed them in winter exclusively with clover hay, linseed-cake, and rape-cake. The milk is set in such a way that the cream shall be got off while it is still perfectly sweet, for they will not churn it if it is in any other condition. The proper temperature for churning, which is from 57° to 60°, is essential, and the churning should not be continued too long. The best butter-makers stop churning at the very moment the butter appears in the form of grains like shot. They pass off the buttermilk through a strainer, then put the butter back with water, give it a few more turns in the churn, strain again, and repeat the operation till the water runs off as clear and bright as when it is put in. Salt is added by weight, at the rate of six pounds of salt to a hundred-weight of butter, by being sprinkled over the butter after it has been spread out in layers; a few turns are given the mass with the butter-worker, and the process is complete.

Diffusion of Bacteria.—M. Miguel has learned from his investigations of bacteria and germs in the atmosphere that the number of bacteria, which is small in the winter, increases through the spring, and becomes large in the summer and fall, then diminishes again during the months of frost. The same is the case with the spores of fungi; but while the molds are abundant during moist periods, the number of aërial bacteria then becomes very small, and does not increase again till the soil has been dried, precisely when the fungoid spores are rare; so that the maxima of mold-microbes and the minima of bacteria-microbes correspond with each other, and *vice versa*. While in the summer and fall a thousand germs of bacteria may often be found in a cubic metre of air, in winter the number falls to four or five, and on some days the dust from two hundred litres of air is incapable of causing the infection of the most alterable liquors. Usually, in M. Miguel's laboratory, the dust of five litres is enough to cause infection, and in the sewers of Paris the particles in one litre will do it. A comparison of the number of deaths in Paris from infectious diseases with the number of bacteria present in the atmosphere showed that every increase of bacteria in the air was followed in about eight days by an increase of the deaths in question. M. Miguel further represents that he has found that the water-vapor which rises from the ground, from rivers, and from masses in full putrefaction, is always micrographically pure, that gases from buried matter in the course of decomposition are always exempt from bacteria, and that even impure air sent through putrefied meat is purified under certain conditions.

The Thread-Worm of the Dog.—The cruel thread-worm (*Filaria immitis*) of the dog was described thirty years ago in the "Proceedings" of the Academy of Natural Sciences of Philadelphia, and has since been repeatedly noticed as infecting dogs in Europe, India, China, Japan, and this country. The heart of a dog, with the ventricles stuffed with the worms, is preserved in the Museum of the University of Pennsylvania. A specimen of the heart and part of one lung of a dog containing the worms has recently been sent to the Academy of Natural Sciences, by Mrs. Laura M. Towne, of Beaufort, South Carolina, who has also furnished a description of the symptoms shown by dogs afflicted with the parasite. She had lost several dogs, and a gentleman living on a neighboring island had lost more than thirty hunting-dogs in two or three years with the same symptoms. The most characteristic symptom appears to be a peculiar cough, which is excited by any movement, especially after sleeping, ending in a violent effort to bring something from the throat, but nothing is thrown up. When they began to run violently, the afflicted dogs would fall down and become stiff and insensible, but would in a short time get up and renew the chase. A large Newfoundland dog grew ill, exhibiting the drowsiness, lassitude, and inclination to turn round and round when he attempted to go anywhere, which marks the conduct of sick dogs, and finally became subject to spasms. He was examined after death, when one *filaria* was found lying at full length in the windpipe, and others were found stretched at length and crowded closely in the large artery. Upon cutting into the heart, the worms burst forth in bunches, slowly uncoiling themselves. They were white, stiff, and wire-like, and not at all stained with blood. The large blood-vessels of the lungs were filled densely, and large *filariæ* were withdrawn with some difficulty even from the small ones. The worms lived in water about twenty-four hours.

Production of Artificial Diamonds.—Mr. Hannay lately gave an account to the Royal Society of his experiments in producing artificial diamonds. As far back as the fall of 1879, he was searching for a solvent of the alkali metals, and tried many experiments with different liquids and gases, with the invariable result that, when the solvent reached the permanently gaseous state, chemical action ensued. A number of experiments were made with sodium, potassium, and lithium, and the hydrocarbons, but the metals almost invariably combined with the hydrogen, setting the carbon free. A series of experiments made with sodium and paraffine-spirit gave a deposit of very hard scales of carbon. This was the reaction upon which the experiments for obtaining crystalline carbon were built. From his experiments in solution, Mr. Hannay concluded that the solvent power of water was determined by two conditions: first, temperature, or molecular *vis viva;* and, second, closeness of the molecules on pressure, which seems to give penetrative power. It should follow, then, that, if one body has a solvent action upon another without acting upon it chemically, such solvent action may be indefinitely increased by increasing the temperature and pressure of the solvent. Out of more than eighty experiments which Mr. Hannay made for producing crystallized carbon, only three were attended by results of a satisfactory nature. The first experiments were made with sodium and paraffine-spirit, in tubes of hydraulic iron, twenty inches long, an inch thick, and of a half-inch bore, three parts filled. The tubes, fitted with screwed plugs, nearly all leaked, and had to be welded up. Then one exploded before it became visibly red, another showed a deposit of scaly carbon, and a third gave out a strong jet of gas when opened, while the iron appeared to have been converted to steel. Concluding that diamonds were not likely to be obtained by that means, Mr. Hannay returned to the idea of dissolving carbon in a gaseous menstruum. A distillation from bone-oil containing nitrogenous bases seemed to him the most likely substance to yield the solvent. It was placed in a strong tube with charcoal, and heated for fourteen hours. The gas rushed out with force on opening the tube, and a few bright particles of carbon appeared, differing but little, however, from particles of wood-charcoal. Another experiment was made with lithium and a mixture of highly rectified bone-oil and paraffine-spirit, placed in a tube twenty inches by four inches, with a bore of half an inch. This was heated for fourteen hours, then cooled slowly. On opening it, after the outrush of gas a little liquid was found, and at the upper end of the tube as it lay in the furnace, a hard, smooth mass, which was removed with a chisel. Some hard particles were found in pulverizing this mass, which, on examination, proved to be transparent crystals of carbon, or diamonds. New experiments were made with other alkali metals, paraffine-spirit, and bone-oil, but they yielded nothing except the scaly carbon. Even the lithium did not act in the same manner as before. This metal having, however, given the best results, Mr. Hannay determined to use it in his further experiments, but was troubled by frequent disasters and explosions, although he again got, in one of the trials, a small quantity of carbon crystals. A curious fact that has been brought out by the examination of the crystallized carbon that was obtained is that nitrogen was present in chemical combination with the carbon. Mr. Hannay is inclined, therefore, to believe that his diamonds were formed by the decomposition of a nitrogenous body, and not by the decomposition of the hydrocarbon. The diamonds, moreover, were not found when nitrogen was absent; but the successful experiments are still too few, and the evidence too vague, to justify drawing any conclusions on this subject.

The Nile and its Ancient Channels.—M. Delamotte, who has made himself well acquainted with the geology and geography of Egypt, has published the opinion that, besides the Nile, that country was watered in prehistoric times by rivers that ran through the present dry sand-channels which the Arabs call Bahr-et-Abied, or rivers without water. The fact that river-shells were discovered in these beds during the French expedition to Egypt lends some support to this view. M. Delamotte has devoted some twenty years to the examination of the subject, and, while he does not undertake to determine when the rivers were dried up, he has reached a conclusion as to the manner in which it was done. He believes that the whole plateau of Khartoum was in prehistoric times a grand lake whence the Nile issued as it now issues from the Victoria and Albert Nyanzas. The cataracts were, however, higher than they are now, and the river, instead of precipitating the whole mass of its waters over the rocks, was divided into streams which found their way through the channels marked by the present Bahr-et-Abiad, and carried the water into the parts of the country which are now desert. The granite and porphyry of the cataract were gradually worn away in the course of ages, their level was lowered, and the Nile, instead of being forced into branch-channels, fell over them and concentrated its waters into its present single stream. M. Delamotte is examining the region of the Upper Nile again, for the purpose of verifying his theory, and of determining if it is possible, by constructing a system of dams and sluices, to raise the level of the cataracts, and cause the waters to flow again through the channels they have deserted.

Sports in the Colors of Squirrels.—A correspondent of "Forest and Stream" relates an interesting instance of the development of varieties of colors in squirrels, which took place in South Carolina several years ago. A Mr. K——, who owned a considerable plantation in the county of Marlborough, had presented to him a pair of milk-white squirrels. His woods were much frequented by gray squirrels, and fox and black squirrels were numerous in the pines and cypress-swamps at some distance from the plantation. The white squirrels bred, producing two young ones, also milk white. The animals were very prolific, under the protection of the owner, who prohibited the intrusion of hunters, and, in course of time, spread to the adjoining plantations, and many of them took to the immense swamps bordering on the Big Peedee River. They also began to sport and change their color, and, from being pure white, became marked with every possible variation of black and white. The correspondent who relates these facts has killed, at various times, at least a dozen thus marked. One of them was of a deep, sparkling black color, except as to the ears and the large, bushy tail, which were snow-white, save a small commingling of the black and white at the root of the tail, and the lower part of the belly and the inner edge of the flanks, which were of a clear ash-gray. The varieties seem to have almost disappeared since the war. In the last individual that the correspondent has noticed, the markings were less pretty and the colors less distinct; the white was turning to ash and the black to brown, the consequence, he supposes, of wild breeding.

A New African Tribe.—Dr. Emil Halub recently addressed the London Geographical Society respecting a hitherto undescribed African tribe called the Marutse. They inhabit the country formerly ruled by the Makololo, described by Dr. Livingstone, who have ceased to exist. Dr. Halub said that when he crossed the Zambesi, and entered into their country, it seemed that he had left Africa, for the tribes were entirely different from the others in South Africa. They belong to the Banti family, but differ from the other members of this family in their appearance, customs, and workmanship. They have their own civilization, independent of influence from white men; and, while the other tribes have nothing which could be called a religion, they believe in a Supreme Being and in a life after death. They call the Supreme Being N'yambe, but have so great a reverence for him that they do not like to pronounce his name. Whenever a serious event happens, as when a man is killed by a buffalo, a crocodile, or an elephant, the common expression is "N'yambe has ordered it, and it is no use resisting." When a member of the royal family was ill, he was taken to the grave of one of his ancestors, when the king knelt on the grave, and prayed to the deceased, "You, my grandfather, who are near to N'yambe, pray to N'yambe that the disease may be taken from this man." When a great disaster happened, as in the case of the river overflowing its banks, the people gathered around the graves of the chiefs, and prayed, "You, who are with N'yambi, pray for us." Previous to the present reign, the king was assisted by a Great Council and a Privy Council, and the cases of persons who were thought to be guilty of crimes deserving capital punishment were submitted to the Great Council for decision. The present king has abolished this usage. This king assumed to have supernatural powers, and the people believed in his pretensions and were afraid of him; but he attempted at one time to exercise his powers publicly to secure the return of some chiefs whom he had condemned to death and who had run away, and failing, lost his reputation. The people are superior to all the South African tribes in the character of their clothing, their skill in working in ivory and metals, and their customs generally. They trade with the other tribes to the north and to the west. They excel the more southern tribes in mental ability, cultivate music, and hold women in high esteem.

Hygienic Conditions of School-Life.—The "Lancet" has undertaken to inquire into the hygienic conditions of school-life in educational establishments, including those in which only the most limited numbers of pupils are taken. Aiming principally to disclose defects which are generally overlooked or little noticed, it invites and expects the coöperation of the conductors of the schools. It has framed a list of questions relating to the character and capacity of the premises, their original purposes and their adaptation to the uses of a school, the accommodations for pupils, provision of air and diet, the hours of school work and the time given wholly to play, the general health of the establishment, and the amount of illness during the year, the appearance or non-appearance of epidemic disease, the sanitary arrangements proper of the establishment, the provisions for isolation in case of a sudden attack of infectious disease, and the system of medical inspection which may be in use. The results of its inquiries as a whole will be given in the form of reports and suggestions with a view of defining, so far as may seem expedient, the conditions of health in body and mind of youth attending school.

NOTES.

Mr. R. E. Earle, of the United States Fish Commission, observed this year that the Spanish mackerel (*Cybium maculatum*) was spawning freely in Chesapeake Bay. He reported his discovery to Professor Baird, and then proceeded to hatch out the spawn with most satisfactory results, getting about half a million of fish in three or four different lots. The fry, which were hatched in water of 84° in eighteen hours after impregnation, seem to be unusually hardy. Preparations will be made to hatch out immense quantities of fish during the next spawning season. The fact is established by these experiments that this fish is quite able to live in brackish water.

Professor E. B. Andrews died at Lancaster, Ohio, on the 21st of August, in his sixtieth year. He was a graduate of Marietta College, in which institution he was Professor of Geology from 1861 until 1869, when he joined the Geological Survey of the State. He is the author of some of the most valuable reports of the survey, and to him is due a careful study of the coal deposits of the southeastern section of the State, and of other of its mineralogical and geological resources.

It was noticed several years ago that, when white light was mixed by the method of rotating disks with ultramarine, the color instead of assuming a paler tint of violet-blue became more violet, and passed, when much white was added, into a pale violet. Professor Rood, of Columbia College, has been trying the results of mixing white with other colors, and has found that, instead of giving lighter shades of the original color, the effects are such as would be produced by adding a quantity of violet light. Thus, vermilion becomes somewhat purplish, orange more red, yellow more orange, yellowish-green more green, green more blue-green, cyan-green less greenish, more bluish, cobalt-blue more of a violet-blue, ultramarine (artificial) more violet, purple less red, more violet. Only greenish-yellow is not changed.

The Society of American Taxidermists, recently organized at Rochester, New York, is believed to be the first of its kind ever established. Its avowed object is to combine the skill and knowledge of taxidermists in the development of their art, and to raise it to a level with the kindred fine arts of painting and sculpture. The first general meeting and exhibition of the Society will be held in Rochester about December 20th, when displays are invited of stuffed animals in groups, single specimens, etc.

Brigadier-General Albert J. Meyer died at Buffalo, the 24th of August, in the fifty-third year of his age. He early turned his attention to the devising of practicable methods of signaling, and rendered efficient service by this means during the war. He was chiefly known to the public by his work in connection with the establishment and development of the present extensive and complete Weather Service, of which he was the chief officer.

A French chemist, M. Alland, has found a way to give a solid and soluble form to sulphuret of carbon, by which it is made much less volatile, more convenient to handle, and more efficacious as an insecticide. He dissolves the sulphuret in a heavy oil which is formed in the manufacture of anthracene and saponifies with lime, and adds quicklime to the solution. The paste thus obtained is soaked in water and dried into a cement which forms an isolating crust. A very effective insecticide, which, however, acts slowly, is thus obtained.

Professor C. W. Borchardt, of the University of Berlin, died at Rüdersdorf, near Berlin, June 27th. He was formerly Professor of Mathematics in the Prussian Military Academy, and had been since 1856 editor of the "Journal for Pure and Applied Mathematics," the oldest of the existing mathematical periodicals.

The President of the Anthropological Institute of London has attempted an explanation of the long-standing and puzzling question of the manner in which the huge and heavy stones which stand as monoliths or in groups as tombs or temples were lifted into their places. Some of the hill tribes of India still erect big stones as memorials, and it is reported of one of them that they recently carried a stone weighing twenty tons up a high hill in the course of a few hours. The ponderous block was inclosed in a wooden framework so arranged that a large number of men could lift all at once, and in this simple way it was borne to the hill-top, a height of four thousand feet.

The London "Times" has tried with success the experiment of having reports of the debates of the House of Commons transmitted by telephone directly to its compositors while they are at work. The notes made by the reporter are read directly into the telephone-receiver in the room adjoining the gallery of the House, and are received by the compositor who sits with his ears near the office terminus of the instrument. The compositor is provided with a system of signals by means of which he can control the rate at which the reports are transmitted to him, and have all the corrections and explanations he may need made on the spot.

M. Charpentier has measured the variation in the intensity of light to which the eye is sensitive, and has found it to be equivalent to about seven or eight hundredths; that is, a given light, whether strong or weak, must be diminished or increased in that degree to give a new sensation distinct from the former one. The difference is essentially the same in direct and indirect vision and with light of every color.

The death is announced of M. Lissajous, Professor of Physics at Toulouse, and author of several valuable scientific memoirs.

According to a recent report of the Boston Board of Health, appreciation of the necessity of good sanitary conditions is steadily increasing in that city. Requests for the inspection of premises are now frequent, while a few years ago obstacles were thrown in the way of inspectors by the landlords. This regard for proper sanitary construction is not confined to any class, but is exhibited alike by the owners of elegant mansions and of the most ordinary dwellings.

Mr. A. A. Breneman has obtained some very satisfactory results in the color decoration of common gray stone-ware. The process was described in a communication to, and samples of the ware exhibited before, the Chemical Section of the American Association at the recent Boston meeting. This sort of ware has hitherto been decorated only in blue, but these samples showed that a wide range of coloring was possible. The process is simple and comparatively inexpensive.

Louis François de Pourtales died at Beverly Farms, Massachusetts, on the 17th of July, in his fifty-seventh year. Since the death of Professor Louis Agassiz, he has been the keeper of the Museum of Comparative Zoölogy at Harvard, and was well known among scientific men for his work in connection with deep-sea dredging.

A statement by Professor Mivart in a recent paper on tails, respecting the non-existence of monkeys in the West Indies, has been shown by correspondents of "Nature" to be an error. Monkeys are found in the islands of St. Christopher and Nevis, and in Grenada, where they exist in large numbers in the wild state, and are very destructive to the growing crops. Apes are also said to be found wild in Montserrat.

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