Dr. ASA FITCH.

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THE

POPULAR SCIENCE MONTHLY.

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THE RECENT PROGRESS OF SOLAR PHYSICS.*

By Professor S. P. LANGLEY,

OF THE ALLEGHENY OBSERVATORY.

LEAVING to those of wider knowledge the survey of the whole field of scientific labor, it has seemed to me that I could best present to you some account of that branch of it with which I am most familiar, which is that of "Solar Physics."

This study is essentially a modern one. Astronomy, which in the earliest times could only mark the annual path of the sun, or count the stars, with the invention of the telescope still concerned itself more with the motions of the heavenly bodies than with their physical nature. It sought out new methods of precision to fix the places of these stars and to mark out for the navigator the path of the moon on the celestial dial; it united itself intimately with the sister science of mathematics in predicting the places of the heavenly bodies from the law of gravitation, but it was still as a surveyor and marker of boundaries in the field of space that the observer chiefly labored, and we associate the most striking triumphs of the classic astronomy with this work of precision. It is this aspect that appeals even to the imagination, and which is seized as distinctive by the poet of Urania:

> "That little Vernier on whose slender lines
> The midnight taper trembles as it shines,
> Tells through the mist where dazzled Mercury burns,
> And marks the spot where Uranus returns."

These are noble aims, and noble results; but it is curious to see how observers of the last century, who had learned this excellent lesson

* Address before the Physical Section of the American Scientific Association at Saratoga

of precision, had learned no other, and remained indifferent to a great question to which the old methods did not apply. We are called into existence by a great central fire, the sun, by which we continue to exist from one hour to another. What is it? what is this heat which it pours into space, and with whose cessation we shall cease? How long will it continue to feed our lives? A few years ago, with almost the sole exceptions of the Herschels and Pouillet, no one even asked these questions, much less intelligently sought their solution.

It is hard to say to whom the awakening of attention is due; yet if any one were to be named, it should perhaps be the Italian physicist Melloni, "the Newton of heat."

His book, "La Thermochrose," has to me an attraction of its own, for the author, with the ingenuous confidence of his nation, begins, not by describing his thermopile or galvanometer, but by taking the reader into his personal experience, and telling him how even as a child he felt an invincible curiosity about what we have just seen hardly any one else then cared for, and how, rising long before dawn, he loved to seek some quiet spot, to wait there in the silence of the sleeping world the first beams of the sun, and as he felt their warmth and heard the stir of life they awakened round him, how he too was stirred with wonder and interest as to the nature of that mysterious thing, radiant heat, and resolved to give his future to its study. If to distinguish a cause for wonder and inquiry in what to the common mind has called for neither be a characteristic of genius, then Melloni must be allowed its possession, and in his but too short years he showed the world how much interest and importance lay in this then neglected study, which so many with clearer knowledge and better methods follow to-day.

Fraunhofer's previous work had prepared the way for the spectroscope, and with the now awakened interest in these questions, its employment by Kirchhoff in 1860 may be said to inaugurate the present study of solar physics, as distinguished from the classic astronomy, which concerned itself with number and measure first, and in a wholly secondary degree with the physical characteristics of the heavenly bodies. This study occupies itself with the former, indeed, but chiefly in aid of other investigations, and by the study of solar physics then, we mean much more than a telescopic examination of the sun; we mean besides this the analysis of its radiations by the spectroscope, their summation by the photometer and thermopile, the determinations of its heat and the possible effects of changes in it on terrestrial meteorology, and generally the pursuit of all those problems which unite the methods of physics and astronomy.

In 1860 we already knew that the sun was surrounded by an envelope then visible only during total eclipses, and which was surmised to be gaseous; and of the sun itself we knew very little more than that it was a hot globe with spots upon it; for, though Schwabe had observed the periodicity of the spots, and Carrington was already at work, their results were not wholly public, and the facts of the variable velocity of the sun's rotation were rather the surmises of a few than part of the body of acquired knowledge. Since then this branch of astronomy has grown almost to the position of an independent science, and, though it has not yet been distinctly divided into specialties in its turn like its elder sisters, yet we already see a tendency to their formations. Thus, with the study of the motions of the solar surface we associate with the names just mentioned those of Sporer, De la Rue, and Wolf; with eye-studies of the photosphere or solar meteorology, those of Dawes, Secchi, and others; with the telescopic use of the spectroscope those of Huggins, Janssen, Lockyer, Secchi, Young, and Tacchini. The work of mapping the spectrum, begun by Kirchhoff, has been continued by Angstrom, Mascart, and Cornu, while photography, in the hands of Rutherfurd, Janssen, and Draper, has largely superseded telescopic studies of the photosphere, and the list might be enlarged indefinitely. Let us glance at part of the work done by these during the past twenty years, for their labors make the history of our study.

The work of Carrington, completed in 1861, taught us what had before been suspected—both the periodicity of the spots and that this great globe, so far as we can see it, has different periods of rotation, its equatorial zones completing a revolution in less time than its polar ones. We know very little more on this point now, the cause of both phenomena remaining wholly mysterious to-day.

In the next year (1862) an impulse was given to the study of the solar surface by the announcement of a supposed discovery of gigantic individual bodies in it, of from 500 to 1,000 miles in length, distinct from each other, and existing in countless numbers. This extraordinary statement was not easily disproved, as it is with great difficulty that the real structure is discernible by the best telescopes. Forms, we can scarcely call them "bodies," are undoubtedly there, of a size and in numbers which could only exist on so vast a surface, and which are no doubt the chief immediate cause of the sun's light and heat —but what are their causes in turn, and what is their real nature? The suggestion was made at the time by the then, perhaps, most eminent living astronomer, that they might be, in a sort, living things—*beings*, in fact, whose vital force gave us the solar heat; a suggestion which we may smile at now, but which was received at the time with a kind of awe, as adumbrating some possible truth. Of its author I would speak with all possible respect in citing it, which I do here, as nothing can better indicate the obscurity of our knowledge, even at so recent a period. We may look back on such a possible suggestion and its connection with that "vital force," now itself banished by physiology, as a kind of landmark on the road we have traveled. Our science, young as it is, is old enough to have had its age of fable.

Since that time, in France, in Italy, in England, and here, thousands of telescopic studies have been made with the purpose of defining these forms, and of learning more about the growth of those mysterious objects with which they are associated—the sun's spots, which drew the attention of Fabricius and Galileo, and which still attract our own more than ever to-day, with problems which seem nearly insoluble. Everything we see convinces us that the solar surface in which they are formed is neither a solid nor a liquid, but composed of volumes of whirling vapors; yet through this vapor, which seems to offer no resistance, come eruptions of explosive violence such as one would suppose must arise from the sudden bursting of some rigid shell. The turmoil within the areas of disturbance is so great, the area itself so vast and inclosing such diversities of action, that we are still doubtful how far this action is downward, how far upward.

Under the circumstances, we can hardly say that twenty years of observation in this department have brought us results commensurate with the labor expended, nor have we derived great aid from photography until some recent advances of which I have presently to speak.

A review of our past studies of the corona is a review of the solar eclipses during the past twenty years; for it is a fact, unparalleled in the sciences of observation, that the opportunities for this knowledge last only minutes, and are separated by intervals of years. Till 1860 it was uncertain whether the protuberances belonged to the sun or moon, but in that year the then newly applied photographic method made it nearly certain that they were parts of the former, and previous surmises that they were extensions of an envelope everywhere surrounding the sun were confirmed. In 1868 some traces of the corona were first photographed. The spectroscope was used upon the prominences, their gaseous nature was proved, and nine of the chromospheric lines were determined; and nearly together Messrs. Janssen and Lockyer made the discovery that these lines could be seen without an eclipse; 1869 brought that eclipse which traversed our own territory, and in this the distinctive coronal line was first observed by Young and by Harkness; while in this, and yet more in the eclipse of 1870 and 1871, we obtained better photographs of the corona, and greatly increased our knowledge of its apparent structure.

It is hardly possible to present even in the briefest way any review here of the separate history of spectroscopic research since 1860, during which time it has been connected with most of the important steps in every field of our study. It has, in the hands of Messrs. Huggins, Zöllner, and Young, made visible to us the forms of the chromosphere, and enabled us to measure the velocity of motions upon the sun otherwise beyond estimate, while at the same time it has given us independent data for the absolute velocity of other suns in space, and for that of the rotation of our own solar photosphere. It has, in the hands of Secchi and others, connected our knowledge of our sun's physical constitution, and perhaps of its past history with that of other suns, and even assumed to give us information whence we might infer something as to their mass, as well as physical constitution, while it has immensely increased the number of lines mapped twenty years since in the spectrum, and modified the ideas we then entertained as to the interpretation of these lines themselves.

The important question of the amount of heat received from the sun has been the subject of almost uninterrupted experiment and study during the period under review, but without essentially altering the data of Herschel and Pouillet which we already possessed. In this field the French physicists and our countryman, Mr. Ericsson, have been prominent workers, and we have attained results possessing all desirable certitude relatively to our knowledge in other branches.

Investigations on the solar temperature have been carried on by many observers, but with results which are thus far less satisfactory.

I am painfully sensible of the inadequacy of this review of the history of solar physics, but the brief time before me warns me to come from its past to its present. Within the last two years the difficulties I have alluded to, as so great in eye-studies of the solar surface, have been singularly modified by the remarkable advance of solar photography at the hands of M. Janssen. When I recently visited his observatory at Meudon, I found him producing original negatives on a scale of nearly thirty English inches to the solar diameter, and which bear enlargement to nearly ten feet with remarkable precision; and one of these negatives, which presents over a million discrete cloud-forms, can be taken in $\frac{1}{3000}$ of a second. In another branch of photography, that of the reproduction of spectral lines, for which so much is due to Rutherfurd and Draper, I know nothing more surprising than the recent success of Captain Abney (of the Royal Engineers) at South Kensington, who has photographed the red end of the spectrum, and far beyond the red end, to a wave-length of about 12,-000. As this statement may of itself convey no clear idea to some of my audience, let me explain in less technical language that it means we can now photograph objects in absolute darkness—objects which are not luminous—simply by the heat they give out. This is a discovery which obviously lends itself to important practical applications, while it is of further interest as bringing another proof of that identity of heat and light, with radiations differing only in wave-length, long since surmised by physicists, and asserted prominently by Dr. John Draper, whose photographs are also the earliest in the path which Captain Abney has carried on by independent methods. Theoretically, there would seem to be no limit to this power of photography so long as objects radiate any heat whatever.

Of recent coronal studies, I have only to speak of the opportunity afforded by the eclipse of last year in our own Western territory. Observed as it was in the pure air of the Rocky Mountains, we found an immense and hitherto almost unsuspected extension of the corona in the direction of the solar equator, such as to make it increasingly probable that the outer corona and the zodiacal light are different appearances with a common origin. The physical constitution of the inner corona seemed to be modified by the weakness or absence of a former constituent, and perhaps we may say that some additional knowledge was gained as to its telescopic structure and its absolute light, while the polariscopic evidence was contradictory.

In the light of our latest knowledge, what, then, is the corona? We do not know. We have literally had but about twenty minutes in the last twenty years to look at it, and from that brief study it remains every way problematical. The extent of this vast solar appendage is unknown, its constitution is unknown, its function is unknown, and it is still uncertain whether we can devise any means for its study which will free us from this dependence upon momentary glimpses. Our only hope, since the most powerful telescope is useless in our lower atmosphere, seems to be to transport our observatory to some mountain-height, like that of Etna or the elevated table-lands of Colorado. There, even, we can not be sure of seeing it without an eclipse; but there, if anywhere, ingenuity will be hopefully employed in an endeavor to remove the difficulties which bar the way. After spending some weeks this year myself upon Mount Etna, on which the new solar observatory is to be built, I can testify to the excellence of such a station; and yet, when we have sites equally good, I can not but regret that it should be left to others to first enter such a promising field.

Of recent spectro-photographic observation, I may mention the valuable work of M. Cornu, who, working at the other extremity of the spectrum from Captain Abney, has extended it beyond the violet to a wave-length of 2,900, far beyond which the solar spectrum probably exists, but where M. Cornu finds our own atmosphere to interpose an almost impassable barrier. The solar spectrum, therefore, is now known by photography through three times the extent of the visible portion, and this great gain on our former knowledge may be said to have been completed for us in the past year.

In last November and subsequently, Mr. Lockyer has made the extremely important announcement that, reasoning from analogies furnished by known compounds, he has been able to show that many elements are really compound bodies, which, incompletely dissociated at the highest temperatures we can command, furnish under the form of feeble lines the spectra of their components.

I do not enter here into discussion of points still in debate; but that which has arisen round this and the recent communications of Dr. Henry Draper, at any rate elicits the evidence of the immense labor now requisite in establishing new facts in our science, and the refinement of some of the adverse explanations suggested in controversy shows us to how limited a company of specialists we must look as judges in matters so important.

The instrumental aids of our study have grown in the period under review with the demand for greater accuracy, until the detached prisms of Kirchhoff's apparatus are replaced by trains of automatically adjustable mechanism, giving us in Thollon's recent instrument the equivalent dispersion of thirty prisms of flint, or what has replaced the "gitter" of Fraunhofer, that wonderful product of skill, the Rutherfurd grating, which for a large variety of uses has already supplanted the prism. Observatories especially devoted to solar physics are being established by European governments, as at Potsdam by Prussia, and at Meudon by France. I have already alluded to that on Etna, and I hope it will not be long before we have a distinctly physical observatory within our own territory. There is no step in our power to take which promises so much for immediate advance as the installation of one in a suitably elevated station, for certain investigations can be made *only* under this condition, and no amount of instrumental appliance, patience, or skill, at a lower altitude, supplies their place.

In now reviewing the acquisitions which this twenty years' labor has brought us, we can not but agree that we have achieved a great deal, and yet must admit, with wonder at the field still before us, how little is our progress in comparison with what remains unknown.

We have found out how to detect daily the outbursts from the sun which were before invisible, but we watch these outpourings of enormous forms without yet knowing what drives them forth, without being sure how far our very view is not in part illusion.

We have learned how to study and fix many of the wonderful details of spot-actions without knowing what spots are. We see them presenting themselves in increasing importance through a term of years, and then diminishing, and we attempt to assign a period to these cycles of growth and decay. This period is often fixed at about eleven years, with a perhaps unjustifiable confidence, for we can not be said to know whether what we have seen in so brief a time is constant or variable, nor whether it be not the mere incident of some greater cycle, whose course began before man was here to see it, and whose term may not be complete till he has gone.

We are possibly now led to ask what our science has taught us on the connection of these remote changes with questions which affect our daily lives, and perhaps to put the utilitarian question, "What is all this worth?"

We find at the present time our study growing into a closer union, not merely with stellar astronomy on the one hand and terrestrial meteorology on the other, but with all the physical sciences, than would once have been supposed possible. Thus, to give a single instance, whatever be the result of the discussions aroused by Mr. Lockyer's statements, it seems likely that we are to look to the analysis of the solar radiations for the most favorable evidence of that resolvability of our so-called elements to simpler forms, which our chemists are now very generally ready to admit as possible.

It is in the solar spectrum that we are now searching for the laws of the molecular groupings which affect the ultimate constitution of matter, and in recent questions as to the real nature of certain terrestrial elements, which our laboratories can not yet deal with, the Mount Sherman observations of Professor Young on the appearance of their analogues in the sun have been accepted by both parties in debates before the Royal Society, as pertinent evidence, the only doubt as to which lies in its interpretation.

Of problems "practical" in the sense that their utility is apparent alike to the learned and the unlearned, there are two at least of the highest importance which now occupy us.

The solar heat, which grows for us the food by which we live, is no doubt in one sense the final cause of every meteorological change, bringing those years of want and years of plenty which are due to local variations of climate, that depend, through a chain of causes very remote and obscure, no doubt, yet finally, upon the sun. We have seen the magnetic needles vibrating all over the globe together at the time of a sudden commotion upon the solar surface; we watch the increase and decrease of auroras, and find we can almost predict their frequency, so apparently united are they by some mysterious bond with the changes of solar spots; and we look with natural hope for other signs of union which may enable us to anticipate more important effects on our meteorology. Extreme pains have been devoted —in some cases misdevoted—to researches aiming to establish such a connection, by collecting data as to the changes in rainfall, the movements of storms, the prices of grain, and of almost every feature of terrestrial meteorology, in order to see whether these run through periods coincident with those of known changes on the solar surface. It will be admitted by the most utilitarian that the end aimed at is a worthy one, for the practical result of success, such as some believe possible, would be to enable its attainer to predict the price of breadstuffs years in advance, to control the markets of the world; to bestow, if unselfish, an almost priceless knowledge to man, or, if self-seeking, to acquire wealth beyond wish.

I need hardly say that the attempt has thus far been unsuccessful. There is hardly any topic on which there is more popular interest, hardly any on which there is more popular error, than this of the supposed influence of the sun on the weather. By means of the study of what Professor Smythe terms the "rain-band" in the spectrum, we appear to have lately gained increased facility in predicting local weather-changes; but, excepting this comparatively unimportant contribution, studies connected with the sun have as yet done very little for us here, and it seems necessary to say that, as far as prophecy is concerned, none of us are yet prophets, or more able to tell from our knowledge of the sun what the weather will be next week than what the harvest will be next year.

There is another utilitarian aspect of our study about which there is less public interest, but more real promise—I mean that which concerns the direct application of solar heat to arts and manufactures. These are now all using it indirectly—by the water, for instance, which it lifts into the clouds to turn the mills of Lowell or Lawrence, as it flows back to the sea, or by the coal which it stored in former ages to drive our engines to-day. These indirect means use but the feeblest portion of the solar heat, which is in theory capable of furnishing nearly one horse-power for each square yard of the earth's surface under full sunshine.

What we have actually realized in experiment is still considerable.

The visitor to the last Paris Exposition may have seen upon its grounds a machine of strange appearance, in the open air, pointing sunward the axis of an immense reflector, shaped like a truncated cone, which gathered the rays to a linear focus upon the boiler of a working steam-engine, which it drove thus by direct solar heat. Many not dissimilar solar engines have been built in this country and in India, the particular one of which I speak, due to M. Mouchot, having actually realized about one horse-power to ten feet square of surface.

We are startled when we make the computation, to find the immensity of the force thus placed at our disposal, or to see what the utilization of the waste places of the earth would bring us. Upon the limited area of the Adirondack wilderness to the north of us, for instance, the daily wasted sun-power actually realizable, and after every allowance for loss, is many times that of all the estimated steam-power at present in use in the whole world. I am not myself so far utilitarian as to wish to see this use made of our pleasant summer haunts, but there are regions of the earth at present as entirely worthless as that great African desert which it is now proposed to partly reconvert to an inland sea, a sunburned area now apparently hopelessly useless to man, and yet on which an amount of power is every year poured in utter waste which could not be made good by the consumption of all the coal known to underlie the soil of Great Britain.

Such machines as those of M. Mouchot, owing to the expense of construction and attendance, cost more than an engine driven by coal, though the sun supplies its power gratis; but it is simply, it seems to me, a question of time when, with another form which I believe our researches already indicate, such engines may become an economical as well as a mechanical success, and in a larger sense it is still only a question of time when the rapidly consuming coal-beds of Great Britain yield their last, and her manufacturing empire is transferred to countries which have not exhausted their supply. But these will exhaust their own in turn; the stock, though great, is finite and not renewable; and we must look, for the only power we know which can replace coal, to those regions of the earth now desolated by solar heat, and to which future empire may probably tend.

We have considered the past and the present of our study; for its future, lies the solution of all the great problems I have already alluded to, but these questions are so interlocked that the complete answer to one will probably not be given till we are nearly ready to answer all.

I have spoken of the fallacy of the popular impression of the result of our study as enabling us to predict the weather, or to anticipate the character of coming harvests. Repeating my belief that we as yet know nothing here, or next to nothing, I yet do not mean to disparage the object of such researches, nor even to deny the possibility of their ultimate success. We can look forward, among other fair dreams for our science's future, to a time when it will enable us to predict the years of plenty or play the part of a beneficent Providence, by warning in season against those of famine, which have cost in our time so many million lives in China and in India. These are, I repeat, still dreams only, but we may call them hopes if we will—hopes of which increased knowledge may deprive us, but of which we can not say it may not bring fruition.

There remains among the greatest problems of the future of our science the all-important one to the whole human race of the future constancy of the sun's heat, of which we have, it seems to me, no assurance of the present rate of supply. We have, it is true, every assurance that in the contraction of the solar mass and in the supply of meteoric matter, we have heat to warm the human race for periods almost beyond limit; but we learn also that this heat is tempered to us by a solar envelope, which seems to be, as far as we know, in conditions which do not favor stability. It is constantly being added to by eruptions from within the sun, caused by we know not what, and constantly diminished by some counter-process which we understand as little. When we consider that the thickening of this solar atmosphere would bring back the age of ice, or its thinning carry our polar regions to tropical temperature, and when we remember that rhythmical action, not uniformity, seems to be the law of nature here, we can feel no certainty of the future constancy of the solar heat, nor of our protection against such changes as seem to have befallen other suns in space, and against which we are powerless to guard.

But such considerations of our ignorance and helplessness, while they may prevent us from any undue pride in what our science has already attained, may teach us renewed confidence from the very brevity of our life. These green fields around us were once covered with glacial ice, and the change has been absolute from that condition to the one of to-day. Yet in the lifetime of any one of the thousands of insect generations which have succeeded each other in these fields, there must have seemed no alteration; and, remembering what instants our own lives are, in a like comparison with the uncounted ages of the sun's history, we may well reckon that our generation shall see no change.

In the little span which is allowed us, however, we will try to learn something more of that source of light, life, and power of which we are materially the creatures; and, if we can leave a knowledge which will not die with ourselves, feel that we have left also the record of a something in us "which owes no homage to the sun."

THE DISEASES OF WILD ANIMALS.*

By Professor JEAN VILAIN.

SOME naturalists have asserted that wild animals, when in a state of liberty, are almost entirely free from disease, and that the latter afflicts them only when in captivity. I know that this is entirely erroneous, and it can be proved that captive wild animals are more exempt from ailments than those roaming at large.

While First Surgeon of the Thirty-first Regiment of the Line, then stationed at Alabera, in Algeria, I dissected the carcasses of about fifty lions. The lungs of twenty of them were affected; one half of them were almost gone, showing that consumption is prevalent among the lions of the Sahara and the Sahel.

At the Jardin des Plantes, here in Paris, seven lions have died since 1869. All of them were born here. I dissected them, and found that their lungs were entirely healthy. To what was the difference due? They received their food regularly, and were carefully protected from inclement weather, while the lions in Africa had to go without food for days, had to inhale the sandy air of the desert, and were frequently drenched by terrible rains.

There is at the Jardin des Plantes a wolf from the Ardennes. He was caught when about six years old. He was suffering from cough, and at one time we thought he was dying. He hawked and spat, and was always sullen and morose. Often he abstained from food for several days. At last we chloroformed him, and examined his throat. He was found to be suffering from nasal catarrh in its most aggravated form. Under proper medical treatment he recovered rapidly. Nine wolves born at the Jardin never showed the slightest sign of disease.

M. Jacquemart, the famous Indian hunter, often told me that he had seen tigers spitting blood, which exhausted them so that they could be approached within a few feet with impunity.

* Translated from the "Revue Zoölogique."

All monkeys are very delicate animals. They are not gluttonous; and having so much exercise, they are rarely afflicted with diseases of the bowels. But they have weak lungs, and the reason why so many of the most interesting among them die when brought to Europe is the too sudden change of air, diet, and water. There is no more intelligent monkey than the chimpanzee, a truly wonderful animal. While in Berlin I dined at the Zoölogical Gardens by the side of a pet chimpanzee. He partook of every dish like a human being, put sugar into his teacup, stirred it with the spoon, and drank the beverage with evident relish. But his eyes looked supernaturally bright. I felt his pulse. It was 125. "He will not live long," I said to his keeper.

"Why not?" he asked with a sorrowful mien.

"He is consumptive," I replied.

"Indeed! He often coughs."

The chimpanzee died a month later. His left lung was entirely gone.

Carnivorous animals suffer from digestive disorders only when fed upon poor meat. I dissected three hyenas: two in Paris, one in London. Their bowels presented an entirely healthy appearance, and so did their stomachs. But the reverse was the case of an old Abyssinian hyena belonging to a Greek menagerie-keeper, who had caught the animal himself in Africa. He managed to keep it alive for two years, but told me: "The beast always vomited, and often lay on the ground, moaning piteously. What was the cause?" I dissected the hyena. The stomach was in a terrible condition. It was dotted with the sears of boils.

Dogs are gluttons. Wild dogs are worse. We have at the Jardin one of these able to devour meat enough to gorge a tiger or a lion; but the animal has to pay dearly for its voracity; it is always suffering from aggravated constipation, and will not live long.

Foxes are shrewd about everything, and so they are about their food. What hunter has ever found a fox that died from disease? Zoölogists admire the dissected body of a fox because there is never anything unhealthy to be found in its organs. Hence, foxes are long-lived.

Six months ago we received at the Jardin four buffaloes from the North American Plains. Two of them died three days after their arrival. They were found to be suffering from a multiplicity of diseases—dyspepsia, imperfect action of the kidneys, and fatty degeneration of the heart. The other two have been ailing ever since, and yet the young buffalo born at the Zoölogical Gardens of Cologne is the embodiment of health.

The elephant is one of the most temperate and abstemious of animals. He eats for his size so little food that it is a wonder how he is able to exist upon it. True, he dies in captivity before his time, but not from physical causes. There is no doubt that he is one of the most sensitive of animals. A slight or a disappointment mortifies him deeply. The elephants of South Africa, which are rough animals when compared with those raised in captivity, die from diarrhœa or constipation, as Le Vaillant has stated. Their tamer brethren are free from disease; and, if they die before their time, they generally do so from the above-mentioned causes. Sultan, the pride of the Jardin, the most amiable elephant I ever knew, was unable to survive the death of his companion, the pet dog Jean.

ON RADIANT MATTER.*

By WILLIAM CROOKES, F. R. S.

I.

TO throw light on the title of this lecture I must go back more than sixty years—to 1816. Faraday, then a mere student and ardent experimentalist, was twenty-four years old, and at this early period of his career he delivered a series of lectures on the general properties of matter, and one of them bore the remarkable title, "On Radiant Matter." The great philosopher's notes of this lecture are to be found in Dr. Bence Jones's "Life and Letters of Faraday," and I will here quote a passage in which he first employs the expression *radiant matter:*

> If we conceive a change as far beyond vaporization as that is above fluidity, and then take into account also the proportional increased extent of alteration as the changes rise, we shall perhaps, if we can form any conception at all, not fall far short of radiant matter; and as in the last conversion many qualities were lost, so here also many more would disappear.

Faraday was evidently engrossed with this far-reaching speculation, for three years later—in 1819—we find him bringing fresh evidence and argument to strengthen his startling hypothesis. His notes are now more extended, and they show that in the intervening three years he had thought much and deeply on this higher form of matter. He first points out that matter may be classed into four states—solid, liquid, gaseous, and radiant—these modifications depending upon differences in their several essential properties. He admits that the existence of radiant matter is as yet unproved, and then proceeds, in a series of ingenious analogical arguments, to show the probability of its existence.†

* A lecture delivered before the British Association for the Advancement of Science, at Sheffield, Friday, August 22, 1879.

† I may now notice a curious progression in physical properties accompanying changes of form, and which is perhaps sufficient to induce, in the inventive and sanguine philoso-

If, in the beginning of this century, we had asked, What is a gas? the answer then would have been that it is matter, expanded and rarefied to such an extent as to be impalpable, save when set in violent motion; invisible, incapable of assuming or of being reduced into any definite form like solids, or of forming drops like liquids; always ready to expand where no resistance is offered, and to contract on being subjected to pressure. Sixty years ago such were the chief attributes assigned to gases. Modern research, however, has greatly enlarged and modified our views on the constitution of these elastic fluids. Gases are now considered to be composed of an almost infinite number of small particles or molecules, which are constantly moving in every direction with velocities of all conceivable magnitudes. As these molecules are exceedingly numerous, it follows that no molecule can move far in any direction without coming in contact with some other molecule. But if we exhaust the air or gas contained in a closed vessel, the number of molecules becomes diminished, and the distance through which any one of them can move without coming in contact with another is increased, the length of the mean free path being inversely proportional to the number of molecules present. The further this process is carried the longer becomes the average distance a molecule can travel before entering into collision; or, in other words, the longer its mean free path, the more the physical properties of the gas or air are modified. Thus, at a certain point, the phenomena of the radiometer become possible, and on pushing the rarefaction still further—i. e., decreasing the number of molecules in a given space and lengthening their mean free path—the experimental results are obtain-

pher, a considerable degree of belief in the association of the radiant form with the others in the set of changes I have mentioned.

As we ascend from the solid to the fluid and gaseous states, physical properties diminish in number and variety, each state losing some of those which belonged to the preceding state. When solids are converted into fluids, all the varieties of hardness and softness are necessarily lost. Crystalline and other shapes are destroyed. Opacity and color frequently give way to a colorless transparency, and a general mobility of particles is conferred.

Passing onward to the gaseous state, still more of the evident characters of bodies are annihilated. The immense differences in their weight almost disappear; the remains of difference in color that were left are lost. Transparency becomes universal, and they are all elastic. They now form but one set of substances, and the varieties of density, hardness, opacity, color, elasticity, and form, which render the number of solids and fluids almost infinite, are now supplied by a few slight variations in weight, and some unimportant shades of color.

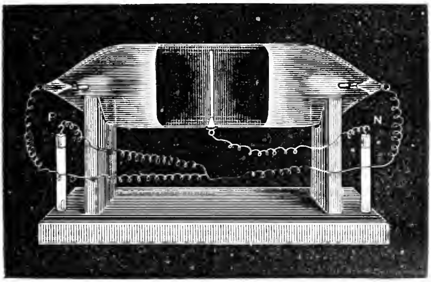
To those, therefore, who admit the radiant form of matter, no difficulty exists in the simplicity of the properties it possesses, but rather an argument in their favor. These persons show you a gradual resignation of properties in the matter we can appreciate as the matter ascends in the scale of forms, and they would be surprised if that effect were to cease at the gaseous state. They point out the greater exertions which Nature makes at each step of the change, and think that, consistently, it ought to be greatest in the passage from the gaseous to the radiant form.—("Life and Letters of Faraday," vol. i., p. 308.)

able to which I am now about to call your attention. So distinct are these phenomena from anything which occurs in air or gas at the ordinary tension, that we are led to assume that we are here brought face to face with matter in a fourth state or condition, a condition as far removed from the state of gas as a gas is from a liquid.

Mean Free Path—Radiant Matter.—I have long believed that a well-known appearance observed in vacuum-tubes is closely related to the phenomena of the mean free path of the molecules. When the negative pole is examined while the discharge from an induction coil is passing through an exhausted tube, a dark space is seen to surround it. This dark space is found to increase and diminish as the vacuum is varied, in the same way that the mean free path of the molecules lengthens and contracts. As the one is perceived by the mind's eye to get greater, so the other is seen by the bodily eye to increase in size; and, if the vacuum is insufficient to permit much play of the molecules before they enter into collision, the passage of electricity shows that the "dark space" has shrunk to small dimensions. We naturally infer that the dark space is the mean free path of the molecules of the residual gas, an inference confirmed by experiment.

I will endeavor to render this "dark space" visible to all present. Here is a tube (Fig. 1), having a pole in the center in the form of a

Fig 1.



metal disk, and other poles at each end. The center pole is made negative, and the two end poles connected together are made the positive terminal. The dark space will be in the center. When the exhaustion is not very great, the dark space extends only a little on each side of the negative pole in the center. When the exhaustion is good, as in the tube before you, and I turn on the coil, the dark space is seen to extend for about an inch on each side of the pole.

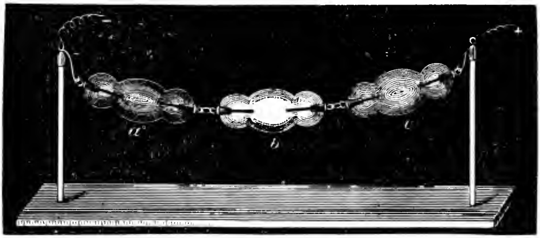
Here, then, we see the induction-spark actually illuminating the lines of molecular pressure caused by the excitement of the negative pole. The thickness of this dark space is the measure of the mean free path between successive collisions of the molecules of the residual gas. The extra velocity with which the negatively electrified molecules rebound from the excited pole keeps back the more slowly moving molecules which are advancing toward that pole. A conflict occurs at the boundary of the dark space, where the luminous margin bears witness to the energy of the discharge.

Therefore the residual gas—or, as I prefer to call it, the gaseous residue—within the dark space is in an entirely different state to that of the residual gas in vessels at a lower degree of exhaustion. To quote the words of our last year's President, in his address at Dublin:

> In the exhausted column we have a vehicle for electricity not constant like an ordinary conductor, but itself modified by the passage of the discharge, and perhaps subject to laws differing materially from those which it obeys at atmospheric pressure.

In the vessels with the lower degree of exhaustion, the length of the mean free path of the molecules is exceedingly small as compared with the dimensions of the bulb, and the properties belonging to the ordinary gaseous state of matter, depending upon constant collisions, can be observed. But in the phenomena now about to be examined, so high is the exhaustion carried that the dark space around the negative pole has widened out till it entirely fills the tube. By great rarefaction the mean free path has become so long that the hits in a given time in comparison to the misses may be disregarded, and the average molecule is now allowed to obey its own motions or laws without interference. The mean free path, in fact, is comparable to the dimensions of the vessel, and we have no longer to deal with a *continuous* portion of matter, as would be the case were the tubes less highly exhausted, but we must here contemplate the molecules *individually*. In these highly exhausted vessels the molecules of the gaseous residue are able to dart across the tube with comparatively few collisions, and

FIG. 2.

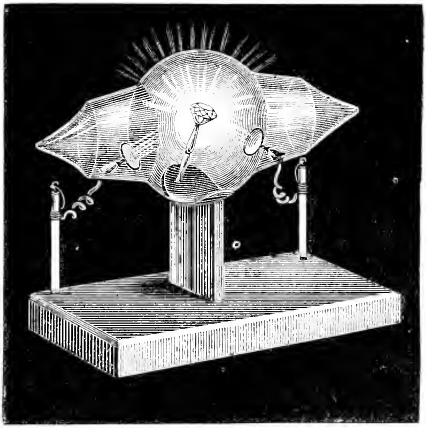


radiating from the pole with enormous velocity, they assume properties so novel and so characteristic as to entirely justify the application of the term borrowed from Faraday, that of *radiant matter*.

Radiant Matter exerts Powerful Phosphorogenic Action where it strikes.—I have mentioned that the radiant matter within the dark space excites luminosity where its velocity is arrested by residual gas outside the dark space. But if no residual gas is left, the molecules will have their velocity arrested by the sides of the glass; and here we come to the first and one of the most noteworthy properties of radiant matter discharged from the negative pole—its power of exciting phosphorescence when it strikes against solid matter. The number of bodies which respond luminously to this molecular bombardment is very great, and the resulting colors are of every variety. Glass, for instance, is highly phosphorescent when exposed to a stream of radiant matter. Here (Fig. 2) are three bulbs composed of different glass: one is uranium glass (*a*), which phosphoresces of a dark-green color; another is English glass (*b*), which phosphoresces of a blue color; and the third (*c*) is soft German glass—of which most of the apparatus before you is made—which phosphoresces of a bright apple-green.

My earlier experiments were almost entirely carried on by the aid of the phosphorescence which glass takes up when it is under the influence of the radiant discharge; but many other substances possess this

Fig. 3.

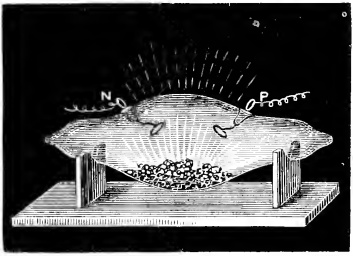


phosphorescent power in a still higher degree than glass. For instance, here is some of the luminous sulphide of calcium prepared according to M. Ed. Becquerel's description. When the sulphide is exposed to light—even candle-light—it phosphoresces for hours with a bluish-white color. It is, however, much more strongly phosphorescent to the molecular discharge in a good vacuum, as you will see when I pass the discharge through this tube.

Other substances besides English, German, and uranium glass, and Becquerel's luminous sulphides, are also phosphorescent. The rare mineral Phenakite (aluminate of glucinum) phosphoresces blue; the mineral Spodumene (a silicate of aluminium and lithium) phosphoresces a rich golden yellow; the emerald gives out a crimson light. But, without exception, the diamond is the most sensitive substance I have yet met for ready and brilliant phosphorescence. Here is a very curious fluorescent diamond, green by daylight, colorless by candle-light. It is mounted in the center of an exhausted bulb (Fig. 3), and the molecular discharge will be directed on it from below upward. On darkening the room you see the diamond shines with as much light as a candle, phosphorescing of a bright green.

Next to the diamond the ruby is one of the most remarkable stones for phosphorescing. In this tube (Fig. 4.) is a fine collection of ruby-

FIG. 4.



pebbles. As soon as the induction-spark is turned on, you will see these rubies shining with a brilliant rich red tone, as if they were glowing hot. It scarcely matters what color the ruby is, to begin with. In this tube of natural rubies there are stones of all colors—the deep-red and also the pale-pink ruby. There are some so pale as to be almost colorless, and some of the highly prized tint of pigeon's blood; but under the impact of radiant matter they all phosphoresce with about the same color.

Now the ruby is nothing but crystallized alumina with a little coloring-matter. In a paper by Ed. Becquerel,* published twenty years ago, he describes the appearance of alumina as glowing with a rich red color in the phosphoroscope. Here is some precipitated alumina prepared in the most careful manner. It has been heated to whiteness, and you see it also glows under the molecular discharge with the same rich red color.

The spectrum of the red light emitted by these varieties of alumina is the same as described by Becquerel twenty years ago. There is one

* "Annales de Chimie et de Physique," third series, vol. lvii., p. 50, 1859.

intense red line, a little below the fixed line B in the spectrum, having a wave-length of about 6,895. There is a continuous spectrum beginning at about B, and a few fainter lines beyond it, but they are so faint in comparison with this red line that they may be neglected. This line is easily seen by examining with a small pocket spectroscope the light reflected from a good ruby.

There is one particular degree of exhaustion more favorable than any other for the development of the properties of radiant matter which are now under examination. Roughly speaking it may be put at the millionth of an atmosphere.* At this degree of exhaustion the phosphorescence is very strong, and after that it begins to diminish until the spark refuses to pass. †

I have here a tube, Fig. 5, which will serve to illustrate the dependence of the phosphorescence of the glass on the degree of exhaus-

*	1·0 millionth of an atmosphere	=	0·00076 millim.
	1315·789 millionths of an atmosphere	=	1·0 millim.
	1,000,000· " " "	=	760·0 millims.
	" " " "	=	1 atmosphere.

† Nearly a hundred years ago, Mr. William Morgan communicated to the Royal Society a paper entitled "Electrical Experiments made to ascertain the Non-conducting Power of a Perfect Vacuum," etc. The following extracts from this paper, which was published in the "Philosophical Transactions" for 1785 (vol. lxxv., p. 272), will be read with interest:

A mercurial gage about fifteen inches long, carefully and accurately boiled till every particle of air was expelled from the inside, was coated with tin-foil five inches down from its sealed end, and being inverted into mercury through a perforation in the brass cap which covered the mouth of the cistern, the whole was cemented together, and the air was exhausted from the inside of the cistern, through a valve in the brass cap, which, producing a perfect vacuum in the gage, formed an instrument peculiarly well adapted for experiments of this kind. Things being thus adjusted (a small wire having been previously fixed on the inside of the cistern to form a communication between the brass cap and the mercury, into which the gage was inverted), the coated end was applied to the conductor of an electrical machine, and, notwithstanding every effort, neither the smallest ray of light, nor the slightest charge, could ever be procured in this exhausted gage.

If the mercury in the gage be imperfectly boiled, the experiment will not succeed; but the color of the electric light, which in air rarefied by an exhauster is always violet or purple, appears in this case of a beautiful green, and, what is very curious, the degree of the air's rarefaction may be nearly determined by this means; for I have known instances, during the course of these experiments, where a small particle of air having found its way into the tube, the electric light became visible, and as usual of a green color; but the charge being often repeated, the gage has at length cracked at its sealed end, and in consequence the external air, by being admitted into the inside, has gradually produced a change in the electric light from green to blue, from blue to indigo, and so on to violet and purple, till the medium has at length become so dense as no longer to be a conductor of electricity. I think there can be little doubt, from the above experiments, of the non-conducting power of a perfect vacuum.

This seems to prove that there is a limit even in the rarefaction of air, which sets bounds to its conducting power; or, in other words, that the particles of air may be so far separated from each other as no longer to be able to transmit the electric fluid; that if they are brought within a certain distance of each other, their conducting power begins, and continually increases till their approach also arrives at its limit.

tion. The two poles are at *a* and *b*, and at the end *c* is a small supplementary tube, connected with the other by a narrow aperture, and containing solid caustic potash. The tube has been exhausted to a very high point, and the potash heated so as to drive off moisture and injure the vacuum. Exhaustion has then been recommenced, and the alternate heating and exhaustion repeated until the tube has been

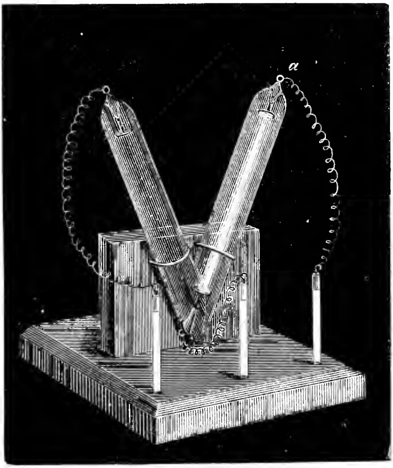
Fig. 5.

brought to the state in which it now appears before you. When the induction spark is first turned on nothing is visible—the vacuum is so high that the tube is non-conducting. I now warm the potash slightly and liberate a trace of aqueous vapor. Instantly conduction commences, and the green phosphorescence flashes out along the length of the tube. I continue the heat, so as to drive off more gas from the potash. The green gets fainter, and now a wave of cloudy luminosity sweeps over the tube, and stratifications appear, which rapidly get narrower, until the spark passes along the tube in the form of a narrow purple line. I take the lamp away, and allow the potash to cool; as it cools, the aqueous vapor, which the heat had driven off, is reabsorbed. The purple line broadens out, and breaks up into fine stratifications; these get wider, and travel toward the potash-tube. Now a wave of green light appears on the glass at the other end, sweeping on and driving the last pale stratification into the potash; and now the tube glows over its whole length with the green phosphorescence. I might keep it before you, and show the green growing fainter and the vacuum becoming non-conducting; but I should detain you too long, as time is required for the absorption of the last traces of vapor by the potash, and I must pass on to the next subject.

Radiant Matter proceeds in Straight Lines.—The radiant matter whose impact on the glass causes an evolution of light, absolutely refuses to turn a corner. Here is a V-shaped tube (Fig. 6), a pole being at each extremity. The pole at the right side (*a*) being negative, you see that the whole of the right arm is flooded with green light, but at the bottom it stops sharply and will not turn the corner to get into the left side. When I reverse the current and make the left pole negative, the green changes to the left side, always following the negative pole and leaving the positive side with scarcely any luminosity.

In the ordinary phenomena exhibited by vacuum-tubes—phenomena with which we are all familiar—it is customary, in order to bring out the striking contrasts of color, to bend the tubes into very elaborate designs. The luminosity caused by the phosphorescence of the residual gas follows all the convolutions into which skillful glass-blowers can manage to twist the glass. The negative pole being at one end and the positive pole at the other, the luminous phenomena seem to depend more on the positive than on the negative at the ordinary exhaus-

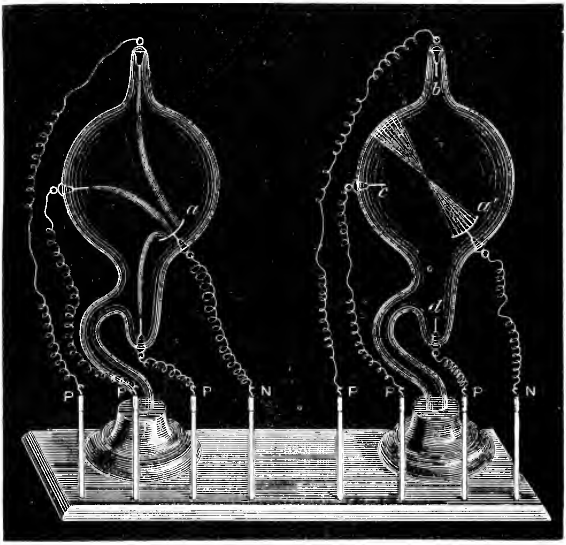
Fig. 6.



tion hitherto used to get the best phenomena of vacuum-tubes. But at a very high exhaustion the phenomena noticed in ordinary vacuum tubes when the induction-spark passes through them—an appearance of cloudy luminosity and of stratifications—disappear entirely. No cloud or fog whatever is seen in the body of the tube, and with such a vacuum as I am working with in these experiments, the only light observed is that from the phosphorescent surface of the glass. I have here two bulbs (Fig. 7), alike in shape and position of poles, the only difference being that one is at an exhaustion equal to a few millimetres of mercury—such a moderate exhaustion as will give the ordinary luminous phenomena—while the other is exhausted to about the millionth of an atmosphere. I will first connect the moderately exhausted bulb (A) with the induction-coil, and retaining the pole at one side (*a*) always negative, I will put the positive wire successively to the other poles with which the bulb is furnished. You see that as I change the position of the positive pole, the line of violet light joining the two poles changes, the electric current always choosing the shortest path between the two poles, and moving about the bulb as I alter the position of the wires.

This, then, is the kind of phenomenon we get in ordinary exhaustions. I will now try the same experiment with a bulb (B) that is very highly exhausted, and, as before, will make the side pole (a') the negative, the top pole (b) being positive. Notice how widely different is the appearance from that shown by the last bulb. The negative pole is in the form of a shallow cup. The molecular rays from the

Fig. 7.

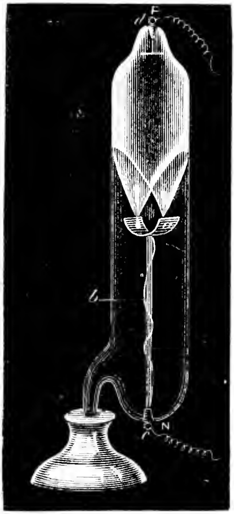


cup cross in the center of the bulb, and thence diverging fall on the opposite side and produce a circular patch of green, phosphorescent light. As I turn the bulb round you will all be able to see the green patch on the glass. Now, observe, I remove the positive wire from the top, and connect it with the side pole (c). The green patch from the divergent negative focus is there still. I now make the lowest pole (d) positive, and the green patch remains where it was at first, unchanged in position or intensity.

We have here another property of radiant matter. In the low vacuum the position of the positive pole is of every importance, while in a high vacuum the position of the positive pole scarcely matters at all; the phenomena seem to depend entirely on the negative pole. If the negative pole points in the direction of the positive, all very well, but if the negative pole is entirely in the opposite direction it is of little consequence; the radiant matter darts all the same in a straight line from the negative.

If, instead of a flat disk, a hemi-cylinder is used for the negative pole, the matter still radiates normal to its surface. The tube before you (Fig. 8) illustrates this property. It contains, as a negative pole, a hemi-cylinder (a) of polished aluminium. This is connected with a fine copper wire, b, ending at the platinum terminal, c. At the upper end of the tube is another terminal, d. The induction-coil is connected so that the hemi-cylinder is negative and the upper pole positive, and when exhausted to a sufficient extent the projection of the molecular rays to a focus is very beautifully shown. The rays of matter being driven from the hemi-cylinder in a direction normal to its surface, come to a focus and then diverge, tracing their path in brilliant green phosphorescence on the surface of the glass.

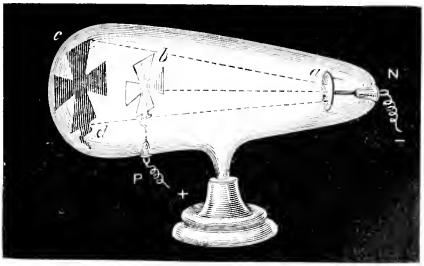
Fig. 8.



Instead of receiving the molecular rays on the glass, I will show you another tube in which the focus falls on a phosphorescent screen. See how brilliantly the lines of discharge shine out, and how intensely the focal point is illuminated, lighting up the table.

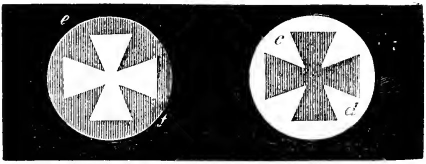
Radiant Matter when intercepted by Solid Matter casts a Shadow.—Radiant matter comes from the pole in straight lines, and does not merely permeate all parts of the tube and fill it with light, as would

Fig. 9.



be the case were the exhaustion less good. Where there is nothing in the way the rays strike the screen and produce phosphorescence, and where solid matter intervenes they are obstructed by it, and a shadow is thrown on the screen. In this pear-shaped bulb (Fig. 9) the negative pole (*a*) is at the pointed end. In the middle is a cross (*b*) cut out of sheet-aluminium, so that the rays from the negative pole projected along the tube will be partly intercepted by the aluminium cross, and will project an image of it on the hemispherical end of the tube which is phosphorescent. I turn on the coil, and you will all see the black shadow of the cross on the luminous end of the bulb (*c*, *d*). Now, the radiant matter from the negative pole has been passing by the side of the aluminium cross to produce the shadow; the glass has been hammered and bombarded till it is appreciably warm, and at the same time another effect has been produced on the glass—its sensibility has been deadened. The glass has got tired, if I may use the expression, by the enforced phosphorescence. A change has been produced by this molecular bombardment which will prevent the glass from responding easily to additional excitement; but the part that the shadow has fallen on is not tired—it has not been phosphorescing at all and is perfectly fresh; therefore, if I throw down this cross—I can easily do so by giving the apparatus a slight jerk, for it has been most ingeniously constructed with a hinge by Mr. Gimingham—and so allow the rays from the negative pole to fall uninterruptedly on to the end of the bulb, you will suddenly see the black cross (*c*, *d*, Fig. 10) change to a luminous one (*e*, *f*), because the background is now only capable

FIG. 10.



of faintly phosphorescing, while the part which had the black shadow on it retains its full phosphorescent power. The stenciled image of the luminous cross unfortunately soon dies out. After a period of rest the glass partly recovers its power of phosphorescing, but it is never so good as it was at first.

Here, therefore, is another important property of radiant matter. It is projected with great velocity from the negative pole, and not only strikes the glass in such a way as to cause it to vibrate and become temporarily luminous while the discharge is going on, but the molecules hammer away with sufficient energy to produce a permanent impression upon the glass.

JOHN STUART MILL.

By ALEXANDER BAIN, LL. D.,
PROFESSOR OF LOGIC IN THE UNIVERSITY OF ABERDEEN.

IV.

THE year 1842 was memorable for the American repudiation, in which Mill was heavily involved. He had invested, I am told, a thousand pounds of his own money, and several thousands of his father's money which he had in trust for the family, and which he would have to make good. The blow completely shook him for the time. From whatever cause, or union of causes, his bodily strength was prostrated to such degree that, before I left London that autumn, he was unequal to his usual walk from the India House home, and took the omnibus before he went far. The disaster must have preyed upon him for a year or more. He alluded to his state in the Comte letters, in which he described his depression as both physical and moral. It appears that in a letter to Comte of the 15th of November, he gave assurances of his being much better. So in writing to me on the 3d of October, he says, "I am quite well and strong, and now walk the whole way to and from Kensington without the self-indulgence of omni*bi*." But on the 5th of December he says, "I have not been very well, but am a little better." He was now in the middle of the very heavy winter's work of getting the "Logic" through the press. There is no more heard of his health till the following June, in which he wrote to Comte in a very depressed tone. I remember, either in that or in the previous summer, his confessing to me that he was in a low state. I naturally urged that he had a long continuance of very heavy work. He replied hastily, "I do not believe any man was ever the worse for work," or something to that effect. I listened in mute astonishment, being quite ignorant that other circumstances besides his intellectual strain were at work. In writing to Comte, who, unlike him, believed in the bad consequences of prolonged study, he said his doctors advised him to rest his brain, but, as they knew so very little, he preferred to abide by his own feelings, which taught him that work was the only thing to counteract melancholy. Comte, however, urged that a "true *positive* therapeutics" involved rest and diversion; and Mill believed in regular holiday tours. It was during this dreadful depression of June and July, 1843, and after the American repudiation had beggared him, that he made his offer of pecuniary assistance to Comte. He had had no holiday for two years, and, except for his customary Sunday walks, he did not leave town that autumn: I suspect that his money affairs had something to do with his still postponing his holiday. In October his letters announce an improved state of health.

His work in 1843, after the publication of the "Logic," was his "Michelet" article, written in autumn. In September he writes: "I am now vigorously at work reviewing Michelet's 'History of France' for the 'Edinburgh.' I hope to *do* Napier, and get him to insert it before he finds out what a fatal thing he is doing." On November 3d he says: "My review of Michelet is in Napier's hands. If he prints it, he will make some of his readers stare." The article appeared in January, and had none of the serious consequences predicted. We have a difficulty, reading it now, to see anything very dreadful in its views. But a philosophic vindication of the Papacy and the celibacy of the clergy, as essential preservatives against barbarism, was not then familiar to the English mind. Mill had worked himself into sympathy with everything French, and echoed the importance of France from the French historians. He always dealt gently with her faults and liberally with her virtues.

While writing this article, he was projecting in his mind his next book, which was to be on the new science, first sketched in the "Logic," to be called "Ethology." With parental fondness, he cherished this subject for a considerable time; regarding it as the foundation and corner-stone of Sociology. "There is no chance," he says, "for social statics, at least until the laws of human character are better treated." A few months later he wrote: "I do not know when I shall be ripe for beginning 'Ethology.' The scheme has not assumed any definite shape with me yet." In fact, it never came to anything; and he seems shortly to have dropped thinking of it. I do not believe there was anything to be got in the direction that he was looking. He was all his life possessed of the idea that differences of character, individual and national, were due to accidents and circumstances that might possibly be, in part, controlled; on this doctrine rested his chief hope in the future. He would not allow that human beings at birth are so very different as they afterward turn out.

His failure with "Ethology" fatally interfered with the larger project, which I have no doubt he entertained, of executing a work on Sociology as a whole. The opinion was long afloat in London that he had such a work in view; but I do not think he ever said so; it was not his way to give out what he was engaged upon, at least before making himself sure of going through with it. That he despaired, for the present at least, of making anything out of "Ethology," at the time I refer to, is proved by his betaking himself soon after to the composition of his "Political Economy."

I have now disposed of all my memoranda relating to 1842 and 1843. The beginning of 1844 saw the publication of the article on Michelet to which I have adverted. In a letter dated 8th of January, I find this upon Beneke: "I am reading a German professor's book on Logic—Beneke is his name—which he has sent to me after reading mine, and which had previously been recommended to me by Austin and by Herschel as in accordance with the spirit of my doctrines. It is so in some degree, though far more psychological than entered into my plans. Though I think much of his psychology unsound for want of his having properly grasped the principle of association (he comes very close to it now and then), there is much of it of a suggestive kind."

From the Comte letters it appears that he had another relapse of his indisposition at this time. Comte earnestly urges him to try a change of climate—Naples or Lisbon—to fortify him for the next few years against "le séjour *spleenique* de Londres." "What is the opinion, I do not say of your doctors, whom you have little faith in, but of those of your friends who are *biologists?*"

I passed three months in London in the summer of 1844, and saw him frequently as before. I have no special recollections of his work this summer. In the autumn he took his long-deferred holiday, and was absent from London two months. He came back quite recruited, and in the course of the winter wrote his admirable article on "The Claims of Labor," which appeared in the "Edinburgh" in the following spring.

I had several letters from him in the winter of 1844-'45, but they say little about himself. He remarks of the review of his "Logic" in the "Eclectic Review," that the reviewer differs from him on the Syllogism which he understands, and agrees with him on the rest of the book without seeming to understand it. He announces with satisfaction, as a most important conquest for Comte, the appearance of Littré's papers in the "National" newspaper. This, however, was immediately followed by his renewed and final exclusion from the Polytechnic examinership; for which one resource was suggested—to start a Positive Review; a scheme that bulks largely in the correspondence for some months, and receives from Mill a qualified support. In March, 1845, he writes to me: "Have you seen Ward's book, 'The Ideal,' etc.? It is a remarkable book in every way, and not the least so because it quotes and puffs me in every chapter, and Comte occasionally, though with deep lamentations over our irreligion." The Comte correspondence shows that he had written to Comte informing him of Mr. Ward's allusions. Comte is very much flattered, and thinks the compliments deserved, because of the justice he had rendered to Catholicism (p. 323).

The summer of 1845 was marked by an interesting incident. In June the British Association met at Cambridge, Sir John Herschel in the chair. I was at the meeting, and listened to Herschel's address. One notable feature in it was the allusion to the recent works on the "Logic of Science," by Whewell and Mill especially, on both of whom Sir John bestowed high encomiums. He also mentioned Comte, but in a very different strain. There was, I remember, a good deal of buzz among Mill's friends that were present, at this unexpected mention of him. Mill was of course extremely gratified on his own account, but considered that Comte was very unfairly handled. Herschel brought up the nebular hypothesis, as advocated by Comte, but treated Comte's mathematics with contempt, and spoke of his book as "a philosophical work of much mathematical pretension, which has lately come into a good deal of notice in this country." To dismiss Comte in this summary fashion, even supposing he had laid himself open by his supposed mathematical proofs of the hypothesis, was a little too strong. Mill naturally thought it an evidence of some weakness in Herschel's mind that he should be so blind to the abundant manifestations of intellectual force in the "Philosophie Positive."* He wrote to Herschel, thanking him for the mention of himself, and remonstrating on his treatment of Comte; but went a little out of his depth in attempting to uphold Comte's calculation. Herschel, in replying, reiterated his approval of the "Logic," stating that it was his intention to have reviewed it in the "Quarterly," as he had done Whewell; but as regarded Comte, he was obdurate, and demolished at a stroke the proof that Mill had relied upon. I think Mill wrote a rejoinder. It is to be hoped that these letters are preserved. Mill copied them and sent them to Comte. It was not the first time that Herschel's name had come up between them; he must have previously written to Mill in acknowledgment of the "Logic." In Comte's letter of date 21st October, 1844 (p. 276), he refers to the information given him by Mill, that Herschel meant to read "mon grand ouvrage," but does not count upon its making a favorable impression, "du moins intense." He then gives the reasons: one being Herschel's prepossessions in favor of sidereal astronomy; the other his analogy to Arago, although "without the charlatanism and immorality of that disastrous personage." Such was the previous reference. The result of his seeing the present correspondence appears on page 362. Comte is very much touched with the zeal displayed by Mill on his behalf; but declines Mill's suggestion that he should himself take up the cudgels in his own defense. Mill, he says, had sufficiently proved, although in a polished way, the malevolent spirit and even the bad faith of Herschel. He is, however, quite satisfied with his former explanation of Herschel's motives, namely, the soreness caused by his discarding sidereal astronomy, on which Herschel's father and himself rested their chief fame.

In the summer of 1845 I became personally acquainted with Grote. For several years previously, Mill appears to have seen little of him,

* The following sentence in Mill's review of "Comte and Positivism" does not apply to the scientific magnates of England, at the date of Herschel's address: "He" (Comte) "has displayed a quantity and quality of mental power, and achieved an amount of success, which have not only won but retained the high admiration of thinkers as radically and strenuously opposed as it is possible to be to nearly the whole of his later tendencies, and to many of his earlier opinions."

but they had now resumed their footing of intimacy. Grote was living chiefly in the country, but when he came into town he made a point of arranging walks and talks with Mill. From the time of my introduction to Grote, I was usually asked to join them. I remember well our first meeting at the London Library, and subsequent walk in Hyde Park. Their conversation took an exceptional turn; how it came I can not exactly remember, but they went over all the leaders of the Reformation, discussing their several characteristics. The subject was not one that either was specially informed upon. As Grote was then on the eve of bringing out the first two volumes of his "History," this was a natural topic; but much more so, after the volumes were out. But Grote was never satisfied if we parted without coming across some question in metaphysics or philosophy. Although his time was mainly given to the "History," he always refreshed his mind at intervals with some philosophic reading or meditation, and had generally a nut to crack when we came together. Plato and Aristotle were never long out of his hands; he was also an assiduous reader of all works on science, especially if they involved the method of science; but the book that was now oftenest in his hands, in the intervals of work, was Mill's "Logic." I doubt if any living man conned and thumbed the book as he did. "John Mill's 'Logic,'" I remember his saying, "is the best book in my library." He had not the same high opinion of any of Mill's other books. He was himself one of nature's logicians; he was a thoroughgoing upholder of the Experience-philosophy, and Mill's "Logic" completely satisfied him on this head. Often and often did he recur to the arguments in favor of *a priori* truth, and he was usually full of fresh and ingenious turns of reply. It was only in Mill that he could find a talker to his mind in this region, as in philosophy generally. Equally intense was his devotion to utility as the basis of morals, and still more varied was his elucidation and defense of the principle; on that topic also he had few that he could declare his whole mind to, and this was another bond of attraction to Mill. Toward himself, on the other side, Mill had an almost filial affection, and generally gave him the earliest intimation of his own plans; but, much as he loved Grote's company, his movements were under the control of a still greater power. Notwithstanding their wide agreement, and numerous bonds of sympathy from this cause, as well as from long intimacy, Grote had always a certain misgiving as to his persistence in the true faith. He would say to me, "Much as I admire John Mill, my admiration is always mixed with fear," meaning that he never knew what unexpected turn Mill might take. This I regarded as an exaggeration due to Grote's gloomy temperament, as well as to the shock of the "Bentham" and "Coleridge" articles; and to Mill's consequent making himself at home with Maurice, Sterling, and Carlyle, with whom Grote never could have the smallest sympathy.

The first opinion held by both that I found occasion to controvert, in those early conversations, was the Helvetius doctrine of the natural equality of human beings in regard of capacity. I believe I induced Grote at last to relax very considerably on the point; but Mill never accommodated his views, as I thought, to the facts. With all his wide knowledge of the human constitution and of human beings, this region of observation must have been to him an utter blank.

This summer (1845) produced the article on Guizot, the last of his series on the French historians (apart from Comte). It seems to have been a great success, even in the point of view of the old "Edinburgh Review" connection, to which it was often an effort to accommodate himself. Jeffrey ("Napier Correspondence," p. 492) is unusually elated with it: "a very remarkable paper," "passages worthy of Macaulay," "the traces of a vigorous and discursive intellect." He did not then know the author; when made aware of the fact, he adds, "Though I have long thought highly of his powers as a reasoner, I scarcely gave him credit for such large and sound views of *realities* and practical results." The reader will remember that the most prominent topic is the Feudal System.

We are now at the commencement of the "Political Economy," which dates from the autumn of this year. The failure of the "Ethology" as a portal to a complete sociology left the way clear for this other project, at a time when his energy was still up to great things. Indoctrinated as he was from babyhood in the subject, and having written on it in articles and discussed it, both in private and in the Political Economy Club, with all the experts of the time, it seemed to offer a fine field for his expository powers. Add to which, he found he could attach to it his views as to the great social questions; although, it must be allowed, the bond of connection was somewhat loose, and the larger sociology would have been a more fitting occasion for such wide-reaching topics.

In a letter dated February, 1846, he announces that the third part of the "Political Economy" is written. He says, in the "Autobiography," that it was the most rapidly written of any of his books; which showed that the subject had been well matured. He turned aside to write an article for the "Edinburgh" on French politics, the text being a series of political papers by Charles Duveyrier. Louis Philippe was now at the height of his prosperity; but the political system was very unsatisfactory: and Mill returned for a little to his old interest in France, and discussed in his usual style the workings of the constitutional system, its weakness and its remedies. His author—a calm, clear-sighted reasoner—put much stress upon a second Chamber made up of old officials, and Mill sympathizes with his object in desiring a counterpoise to democracy; but remarks, with his usual acuteness, "It is not the uncontrolled ascendancy of popular power, but of any power, which is formidable." The article came out in

April, 1846. It appears that the editor thought fit to omit a passage controverting the prevailing notion of the warlike propensity of the French. Mill wished the passage had been retained: "The opinion is a very old and firm one with me, founded on a good deal of personal observation." He adds, "The 'Edinburgh' has lately been sometimes very unjust to the French." He further interrupted the "Political Economy" to write his review of Grote's first two volumes, which appeared in the "Edinburgh" in October. This was, in every sense, a labor of love—love of the subject, love of the author, and admiration of the work. Writing in September, he says: "I have just corrected the proof of my review of Grote, in which I have introduced no little of the Comtean philosophy of religion. Altogether I like the thing, though I wrote it in exactly four days, and rewrote it in three more, but I had to read and think a good deal for it first." His reading, I remember, included the whole of the Iliad and Odyssey, for the sake of the Homeric discussion in which he perilously ventured to differ somewhat from Grote. There was no man whose opinion Grote was more sensitive to, but the objections raised did not alter his views. In deference to Mill, he made some slight changes in the next edition. One, I remember, was to leave out of the preface the words "feminine" and "masculine," as a figurative expression of the contrast of the artistic and scientific sides of the Greek mind. Mill could never endure the differences of character between men and women to be treated as a matter of course.

In the letter above quoted, he announces that he has "got on well with the 'Pol. Ec.' I am on the point of finishing the third book (Exchange)." He was now beginning his hardest winter, after 1842–'43. It was the winter of the Irish famine, and he thought he saw an opportunity for a grand regenerating operation in Ireland. He began in the "Morning Chronicle" a series of leading articles, urging the reclamation of the waste land to be converted into peasant properties, and iterated all the facts showing the potency of the proprietary feeling in strengthening the disposition to industry. In the months of October, November, December, and January, he wrote two or three leaders a week on this topic; we used to call these, in the language of the medical schools, his "Clinical Lectures." He was pushing on the "Political Economy" at the same time. Moreover, a letter to his brother James (2d November) shows that he was laboring under illness—"had been ill, now better, but still a bad cold." In the middle of November he wrote that the articles "have excited a good deal of notice, and have quite snatched the initiative out of the 'Times.' He adds: "It is a capital thing to have the power of writing leaders in the 'Chronicle' whenever I like, which I can always do. The paper has tried for years to get me to write to it, but it has not suited me to do it before, except once in six months or so." On the 28th of December, he says: "I continue to carry on the 'Pol. Econ.' as well as I can with the articles in the 'Chronicle.' These last I may a little slacken now, having in a great measure, as far as may be judged by appearances, carried my point, viz., to have the waste lands reclaimed and parceled out in small properties among the best part of the peasantry." In another month he changes his tune. On the 27th January (1847) he writes: "You will have seen by this time how far the Ministry are from having adopted any of my conclusions about Ireland, though Lord J. Russell subscribes openly to almost all the premises. I have little hope left. The tendency of their measures seems to me such that they can only bring about good to Ireland by excess of evil. I have so indoctrinated the 'Chronicle' writers with my ideas on Ireland that they are now going on very well and spiritedly without me, which enables me to work much at the 'Political Economy,' to my own satisfaction. The last thing I did for the 'Chronicle' was a thorough refutation, in three long articles, of Crocker's article on the Division of Property in France." Two months later, he announced that the first draft of the "Political Economy" was finished. As to public affairs: "The people are all mad, and nothing will bring them to their senses but the terrible consequences they are certain to bring on themselves, as shown in Whately's speech yesterday in the House of Lords—the only sensible speech yet made in either House on the question. Fontenelle said that mankind must pass through all forms of error before arriving at truth. The form of error we are now possessed by is that of making *all* take care of *each*, instead of stimulating and helping each to take care of himself; and now this is going to be put to a terrible trial, which will bring it to a crisis and a termination sooner than could otherwise have been hoped for."

Before passing from this memorable winter, I may mention that Liebig, in a reprint of his "Animal Chemistry," handsomely repaid the notice taken of his researches in the "Logic," saying of his amended views that "he feels that he can claim no other merit than that of having applied to some special cases, and carried out further than had previously been done those principles of research in natural science which have been laid down" in Mill's book. Mill exultingly remarked: "The tree may be known by its fruits. Schelling and Hegel have done nothing of the kind."

Before arriving in London this year, I had another letter (5th of May). He delays to commence rewriting till he sees the upshot of the Irish business. "The conduct of the Ministers is wretched beyond measure upon all subjects; nothing but the meanest truckling at a time when a man with a decided opinion could carry almost anything triumphantly." I saw him as usual during the summer, but do not remember any incidents of importance. Grote was in town for several weeks on the publication of his third and fourth volumes, which was a new excitement. I went down to Scotland in the autumn, but having no longer any teaching-appointment there, I returned to London in

November, and entered the Government service, and was therefore in constant residence until I saw fit to resign in 1850. For this interval, I have not the advantage of possessing any letters from Mill, and can only give a few scattered recollections of the more impressive occurrences.

The "Political Economy" was published in the beginning of 1848. I am not about to criticise the work, as I mean to do the subsequent writings, but I have a few remarks to make upon it. One modification in the laying out of the subject he owes, as I have already said, to Comte's sociological distinction into Statics and Dynamics. This is shown in the commencement of the fifth book, entitled "The Influence of the Progress of Society in Production and Distribution." I can believe, although I am not a political economist, that this distinction may have been as useful in political economy as in politics. He spoke of it to me at the time as a great improvement.

But what I remember most vividly of his talk pending the publication of the work, was his expectation of a tremendous outcry about his doctrines on property. He frequently spoke of his proposals as to inheritance and bequest, which, if carried out, would pull down all large fortunes in two generations. To his surprise, however, this part of the book made no sensation at all. I can not now undertake to assign the reason. Probably people thought it the dream of a future too distant to affect the living; or else that the views were too wild and revolutionary to be entertained. One thing strikes me in the chapter on property. In section 3, he appears to intimate that the children even of the wealthy should be thrown upon their own exertions for the difference between a bare individual maintenance and what would be requisite to support a family; while in the next section he contemplates "a great multiplication of families in *easy circumstances*, with the advantage of *leisure*, and all the real enjoyments which wealth can give, except those of vanity." The first case would be met by from two to five hundred pounds a year; the second supposes from one to two thousand. The whole speculation seems to me inadequately worked out. The question of the existence of large fortunes is necessarily a very complex one; and I should like that he had examined it fully, which I do not think he ever did.

His views of the elevation of the working-classes on Malthusian principles have been much more widely canvassed. But there is still a veil of ambiguity over his meaning. Malthus himself, and some of his followers, such as Thomas Chalmers, regarded late marriages as the proper means of restricting numbers; an extension to the lower classes of the same prudence that maintains the position of the upper and middle classes. Mill prescribes a further pitch of self-denial, the continence of married couples. At least, such is the more obvious interpretation to be put upon his language. It was the opinion of many, that while his estimate of pure sentimental affection was more than enough, his estimate of the sexual passion fell a good deal below the truth.

The strong leanings toward some form of socialism, indicated in the "Autobiography," would have led us to believe that his opinions nearly coincided with those of the Socialists commonly so called. The recent publication of his first draft of a projected essay on the subject shows the wide gulf that still separated him and them. The obstacles to the realizing of socialistic schemes could not be more forcibly expressed. Above all, the great stress that he always put upon individuality would be almost impossible to reconcile with the constructions of Fourier, Owen, Louis Blanc, and the American communities. His socialism is thus to be the outcome of a remote future, when human beings shall have made a great stride in moral education, or, as Mr. Spencer would express it, have evolved a new and advanced phase of altruism.

The publication of the "Political Economy" was followed by another very serious break-down in his health. In the summer of 1848, an affection of the thigh (I am not sure whether it began in a hurt) was treated by his doctor with iodine; the consequence of which was a speedy impairment of his eyesight. I remember him in a state of despair from the double misery of lameness and blindness. His elasticity of constitution brought him through once more; but in the following year (1849) he was still in an invalid condition. I introduced to him that year Dr. Thomas Clark, of Marischal College, himself a permanent invalid from overwork, who spoke a good deal to him about regimen, and endeavored to induce him to try the water-treatment, then just started. He was, however, not to be moved from his accustomed routine. His view of the medical art (at the time I speak of) was, that it should restore a shattered frame by something like magic. In other respects, his intercourse with Clark gratified him much, and led to a permanent friendship.

His work, as a great originator, in my opinion, was now done. The two books now before the world were the great constructions that his accumulated stores had prepared him for; and I do not think that there lay in him the materials of a third at all approaching to these. It is very unlikely indeed that he was even physically capable of renewing the strain of the two winters—1842–'43 and 1846–'47. His subsequent years were marked by diminished labors on the whole; while the direction of these labors was toward application, exposition, and polemic rather than origination; and he was more and more absorbed in the outlook for social improvements. Not that his later writings are deficient in stamina or in value; as sources of public instruction and practical guidance in the greatest interests of society, they will long hold their place. But it was not within the compass of his energies to repeat the impression made by him in 1843 and again in 1848. We must remember that all through his severest struggles, he had a public official duty, and spent six hours every day in the air of Leadenhall Street; and although he always affected to make light of this, or even to treat the office-work as a refreshing change from study, yet when his constitution was once broken, it would tell upon him more than his peculiar theories of health and work would let him confess.

In another article, I propose to review the writings subsequent to the date now reached.

OCEAN METEOROLOGY.

By Lieutenant T. A. LYONS, U. S. N.

WERE the captain of a ship to contemplate making a passage in a sea he had never before traversed, he would find it desirable to be supplied with charts of two different kinds: one kind showing the rocks, shoals, and other dangers scattered throughout its expanse, the contour of its islands and bounding shores, and the soundings of its shallow waters; the other kind giving full and reliable information regarding its winds and weather, storms and currents, barometric and thermometric fluctuations. The first is essential to safe navigation; the second an invaluable auxiliary to a speedy passage. It is of this second kind—meteorological charts—that this article is to treat.

And, first, partly to introduce the subject, partly to illustrate it, I will very briefly touch upon a similar work for the land—a work which has now become familiar to all—I mean the daily synopsis and forecast of the weather published by the United States and several European Governments for the benefit of their people.

The value of an extensive organization for observing atmospheric phenomena was early appreciated in Europe, and as long ago as the year 1780 the Society of the Palatinate was established under the auspices of the Elector Charles Theodore, who entered with spirit and ability into its pursuits, and furnished it with the means of defraying the expense of instruments of the best construction, which were gratuitously distributed to all parts of Europe, and even to America. Some idea may be formed of the comprehensive scale of the journal of this society, when it is known that it contains observations three times in the day of the barometer, thermometer in the shade and in the sun, hygrometer, magnetic needle, direction and force of the wind, quantity of rain and of evaporation, the height of any neighboring water, the changes of the moon, the appearance of the sky, and the occurrence of meteors and of the aurora borealis. To these must be added, in some places, observations upon the electrical state of the atmosphere, upon the progress of vegetation, the prevalence of disease, changes of population, and migration of animals. The field of observation extended from the Ural Mountains in the east to Cambridge, in the United States, in the west; and from Greenland and Norway in the north to Rome in the south. This range included also stations upon three high mountains in Bavaria and upon the summit of St. Gothard. The observations of each year are summed up and compared with those which precede, in copious and most laborious tables of mean and extreme results, and many very interesting essays upon various branches of meteorology are interspersed throughout the volumes of the society.

Unfortunately for science, the secretary, Hemmer, died in the month of May, 1790, and from that time the society appears to have languished, and finally to have become extinct amid the troubles and the wars of the French Revolution.*

It might be of interest to trace the progress of meteorology since the days of the Palatinate Society—to recount the many improvements in the instruments, the new auxiliaries impressed into its service, the successive unfolding of its laws as immense masses of data came into view, and the gradual passing of the subject from the care of amateurs, who pursued it mostly as a pastime or matter of curious inquiry, into trained hands and organized bodies maintained by liberal government support. But this is not my purpose here: with a passing glance at an important guide-post erected about the year 1840 on the highway of this science, I will make a single stride over all this field and come at once to the problem proposed to the meteorologist of the present day, and the means at his command for its solution.

The writer of this guide to the way beyond gives in clear-cut outline all that has since been realized both in this country and England. After stating the necessity of making observations on land coördinate with those at sea, in order to study the atmosphere in its entirety, he uses these prophetic words: "This extension of the system landward was proposed in the beginning as a part of the original plan. I have never ceased to advocate it since, and to couple with it a system of daily weather reports through the telegraph. As much as we have accomplished at sea, more yet can be accomplished through the magnetic telegraph on the land. With a properly devised system of meteorological observations to be made at certain stations wherever the telegraph spreads its meshes, and to be reported daily by telegrams to a properly organized office, the shipping in the harbors of our seaport towns, the husbandman in the field, and the traveler on the road, may all be warned of every extensive storm that visits our shores, and while yet it is a great way off. The laurels to be anticipated from such extension of our beautiful field of research would crown the results

* For these particulars of the Society of the Palatinate I am indebted to the valuable treatise on meteorology by the late Professor John Frederick Daniell, of England.

already obtained, and probably entitle the whole to be regarded as among the most splendid achievements of the age. With this system established, and conducted as it ought to be, no ship need ever put to sea from any of our seaports in ignorance of the approaching storm. A like system for the British Islands and the Continent would lead to like results there ; many storms, after visiting our shores, travel across the ocean and carry devastation there. Should the sub-Atlantic telegraph be laid, and, when laid, should it answer its ends, warnings of all such storms may be sent across the ocean several days in advance." —("Sailing Directions," by Lieutenant M. F. Maury, U. S. N., vol. i., p. viii. of Introduction.)

To recur to the problem of the meteorologist of to-day, it assumes three distinct phases : first, from a number of observations extending through many years and over a large expanse of land or sea, to discover the laws of atmospheric phenomena ; second, from an unbroken series of observations at any one place, through a sufficiently long period to eliminate all merely adventitious changes, to determine the climate of that place ; and third, from a number of simultaneous observations at different points of any circumscribed area, to predict what the weather will be over that area for any short time.

The solution of the first phase is all but complete : the great governing principles of our atmosphere are now quite well known—it is only the details that need defining. That of the second phase can scarcely be said to be more than begun : in only a few places on the globe have accurate observations been continued for a long enough period to reliably define their climates ; but of late years, especially during the last twenty, such an interest has been awakened in this subject, that ere the century closes very many cities will possess the data for thoroughly describing the atmospheric changes to which they are subject, not according to the recollection of the oldest inhabitant, but by accurate records—figures that never deceive.

The effect of the weather upon mankind is only too well known : with the invalid or convalescent it is often a matter of life or death ; with us all, how different our feelings on a fresh, genial day, when the air is dry and bracing, and a bright sun illumines an azure sky—how elastic, how full of vigor are we, compared with the lethargy that seizes us in somber, bleak weather, when dense, misty clouds hang in heavy folds around us, and shade even our very sensations with their gloom !

In Boston, the *east* wind of spring and autumn is a source of annoyance to its inhabitants; it comes laden with moisture and—coughs. In California, it is an equally unwelcome visitor, but for a very different reason : it parches and all but cracks the skin. In both places, the relative prevalence of this wind is a fact important to know. In Buffalo, the storms that sweep in from the lakes are disagreeable in the extreme ; in Texas, the fierce blast of the norther is often very destructive. But all these instances are peculiarities singled out from a variety of items, highly interesting to any one contemplating either a temporary or permanent residence in a place new to him. The storms, the rain, and the snow he has to encounter; the average humidity and tenuity of the air he has to breathe; the variety and character of the winds that are to blow upon him; the mean and extreme of the daily, monthly, and yearly temperature to which he will be subjected; the relative number of cloudy and clear days—all this, constituting the climate of a place, should be known to one ere he hazards his comfort, his good feeling, or, it may be, his health, by a change of residence. And it is probable that, with the great number of observers now carefully noting and recording these items in various cities, the day is not far distant when their laborious experience of long years will be classified, reduced, and published in such a compendious form, that a stranger to any given place may, by half an hour's study of this publication, inform himself correctly as to its climate.

The solution of the third phase of the problem is the one productive of most immediate benefit to all, how much soever their callings may differ; and this universal interest warrants my stating its conditions more at length than I have done with the other two. This phase may be likened unto an algebraic equation—a combination of known and unknown quantities, which, being operated upon according to certain rules, gives a desired result.

First, to determine the known quantities, a variety of instruments must be read and recorded at stated periods. These are, anemometers, to indicate the direction and velocity of the wind; barometers, to measure the pressure of the air; and hygrometers, its humidity. Suppose sets of these, standard in quality, to be furnished a corps of trained observers stationed at various points throughout a given area, say a thousand square miles; let each observer note his instruments at predetermined hours, or, better, let the observation be automatic and continuous, which is now often done by means of mechanical contrivances; let a network of telegraphy connect all the stations with some central point: then, at any moment he wishes, a person at this point can ascertain the prevailing weather all over the area, or, in other words, the known quantities of his equation. Now, the atmosphere that encircles our globe is but an ocean of less density than the watery element that surges upon its surface; like that, it moves, contracts, and expands according to well-known physical laws, and these laws constitute the rules whereby the person at the central station operates on his known quantities, solves the equation, and obtains for a result the forecast of the weather for the next few hours.

Having a due regard for the conformation of the ground over which his prognostics extend, he well knows that, according to the relative variation of pressure, temperature, and moisture, there will be a corresponding variability of weather: that if the pressure is great at one place and slight at another, the air will as naturally flow from the former toward the latter as water will down an inclined plane; and as the velocity of the water will depend on the inclination of the plane, so will the violence of the wind be chiefly due to the difference of pressure: hence the direction and force of the wind are predicted. Again, whether the day will be warm or cold depends mostly on the temperature of this wind; and, furthermore, if it contains much vapor and blows toward a point where the temperature is lower than that from which it started, clouds, or rain, or snow will follow, according to the difference of temperature and the supply of vapor; but if a saturated wind blows toward a place where the temperature is high, and air dry, its moisture will be licked up by the thirsty air, and a mere haze will ensue, or clear weather continue.

This problem in its ever-varying conditions is the one daily solved by the Weather Bureaus of several Governments, in the interest of agriculture, comfort, and commerce; and perhaps nowhere more successfully than by our own. With its large corps of trained observers, its military discipline, variety of standard instruments, extensive field of operations covered by telegraphic lines, liberal Government support, and educated intelligence to guide the whole, there is every reason for the confidence so generally felt in the weather prognostics of the Signal Office of the United States Army.

With this preliminary glance at meteorology on the land, I shall now pass to a consideration of it as regards the ocean—the subject proper of this article; and as I have already divided the problem into three phases, it will be convenient to maintain this distinction—only, that for the ocean, the cases reduce to two: first, to seek out the hidden cause of the winds, whether as the gentle trades that scarcely ruffle the waters over which they glide, or as the violent hurricane that lashes the waves into a tempest of confusion; and, secondly, to determine the many items that, together, make up the climate of small areas of every sea.

The third phase of the problem on land is entirely excluded from the ocean. There we can not establish fixed stations and spread a web of electric wire over them, with some guiding genius ensconced in the midst. We can not (as is done every morning in the United States, England, France, and Germany, for the limits of each country) say what the weather will be, and how the winds will blow, for the ensuing twenty-four hours, in the Indian Ocean, the South Seas, or the North Atlantic. But we *can* give information yielding in no degree in importance to this purely ephemeral benefit; and the manner in which this is obtained and published is what I shall fully describe hereafter.

To the late Commander M. F. Maury, of the United States Navy, is due the credit of having given to ocean meteorology that vigorous impulse that placed it in the foremost rank of pursuits, and justly obtained for its advocate his distinction in this branch of physical science. He planted a germ which, under his own assiduous care, grew and overspread the globe: its seed fell in every maritime nation, and to-day they are producing meteorological charts of the ocean—all modifications or elaborations of his useful idea. It is therefore but proper that I should here give a short sketch of both himself and his great work.

Matthew Fontaine Maury was born in Virginia, January 4, 1806. He entered the navy as midshipman in 1825, and was promoted to the grade of lieutenant in 1836, having in the interval been attached to various cruising-vessels, on which he performed the customary duties of a sea officer. It was during one of these cruises that the outline of his future work acquired form and shape in his brain.

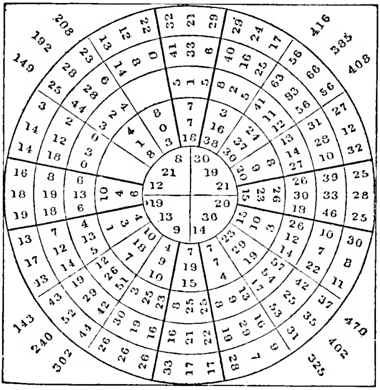
In 1839 an accident permanently incapacitated him for further service at sea, and he was therefore given charge of the depot of charts and instruments in Washington: this was soon afterward united to the Naval Observatory, and he became superintendent of both, retaining the position uninterruptedly until 1861—a period of more than twenty years. Later still, the scope, character, and importance of the chart department grew to such dimensions as to necessitate its separation from the observatory: this was done, and it became the Hydrographic Office, which it continues to this day, under the management of a naval officer. At present, it has no closer intimacy with the observatory than being under the guidance of officers of the same branch of the Government—the navy.

Maury was promoted to the grade of commander in 1855, and it was then also that he attained the height of his scientific fame: he had written his "Physical Geography of the Sea"; he had been chiefly instrumental in bringing about the Brussels Conference, whereby the civilized nations of the world entered into his plan of "ocean meteorology"; he had prepared his ponderous volumes of "Sailing Directions"; he had received the encomiums of numerous scientific bodies both native and foreign; and, with the constant aid of a large number of naval officers, he had compiled, with incredible labor and pains, that series of charts that has made his name so familiar to sailors, whatever the flag they sail under.

On the 1st of February, 1873, after having done more than any other man that preceded him toward tracing the wind in its circuits, and showing the navigator how to take advantage thereof, he died at Lexington, Virginia, in the sixty-eighth year of his age.

I will now give an outline of the charts compiled under Maury's direction. A full description would necessitate the reproduction of specimen-sheets, and that is impracticable here.

First and most important are the Pilot Charts. These give for small areas of ocean—every five degrees square—the relative frequency of different winds during each month. The following figure is a sample square of the whole series, and a few explanatory words will disentangle this web of figures. The radii extending from the inner to the outer circle inclose sixteen points of the compass—as north, north-northeast, northeast, etc. Every two concentric circles contain the data for each season. The problem being, then, to compare the relative prevalence of the *same* wind in different months, it is done as follows: suppose it a northerly wind; looking at the figures between



the two radii opening toward the top and between the outer and second circles, we see that, of periods of eight hours each, there were 32 in December, 21 in January, and 29 in February; the figures between the same radii and the second and third circles show that there were 41 periods in March, 33 in April, and 6 in May; and similarly, for each wind between every two radii. To compare *different* winds for the same month, say December, we look at the first figure to the left in each space between the outer and second circles, and find that, of periods of eight hours each, the wind was 32 times from the north, 29 times from north-northeast, 56 from northeast, and so on round the compass.

The figures 416, 385, and 408, in the upper right-hand corner, denote the total number of observations in December, January, and February, respectively; and similarly for the other months in the other corners. The figures in the center express the periods of calm in the several months.

Though this arrangement is compact and ingenious, still, when we come to make the comparison that is the real object of the chart, viz., the relative frequency of different winds in several adjoining squares, we find the task a little irksome.

Second, the Thermal Charts. These show the temperature of the sea-water at the surface for every month, isothermal lines bring drawn at every 10° from 40° to 80° Fahr. By using three colors, and a different arrangement of the figures for each season, all the observations of each month are made separately visible on one sheet in the spot where taken. The sheet thus appears to the eye a continued intermingling of curves and figures—blue, red, and black—generally open and easily traced where the observations are moderate in number, but an inextricable tangle where frequent.

As difference of temperature in adjacent portions of the sea indicates difference of density, which in turn denotes a mobility of the waters, that is, oceanic currents, these currents are therefore indirectly shown by this series of charts.

Third, the Track Charts. Such a quantity and variety of information is crowded into these, that I despair of giving any intelligible idea of them.

Imagine an artist perched a thousand feet above the center of New York and provided with canvas on which to delineate the city below—to trace in outline every street, house, and tree; every railway and telegraph line; all the moving objects, man, horse, and vehicle—what a complicated picture it would make! Yet this would by no means represent the intricacy of the network on the Track Charts. On them the experience of a large number of *all* the vessels that sailed the ocean for a period of fifty years is spread before us. Most prominent are their jagged courses from port to port; along these are symbols to represent the direction and force of the wind: roman numerals to express the magnetic variation; arrows and figures to indicate the set and strength of currents; figures to show the temperature of the sea-water; great circle routes; trade-wind limits; the name of each ship and date of making the passage—and all this in distinctive colors and peculiarity of line, so that each item can be determined with great exactness as regards both time and space.

Indeed, this profuse interweaving and crossing of lines and figures taxes the patience of even the most painstaking mariner. What the charts show forcibly at a glance, are the great ocean highways, but this chiefly by the multiplicity of tracks through the beaten paths, compared with their sparseness over less frequented routes.

Fourth, the Storm and Rain Charts. For every five degrees square and each month, they clearly show the relative prevalence (compared with the whole period of observation) of the following phenomena: gales from eight cardinal points of the compass, calms, fogs, thunder and lightning, and rain (including hail, snow, and sleet).

The arrangement of these charts is excellent, and they are easily understood.

Fifth and last of the entire set, the Trade-Wind Charts of the Atlantic Ocean. By a judicious use of colors, figures, and lines, the limits of both trades, of the calm belt between, and of the calm zone on the outer border of each system of trades, together with the several observations by which these limits were determined, are all clearly and distinctly shown for each month, on a single sheet.

In 1863 the publication of Maury's charts was discontinued; but in 1876 other charts, similar in nature, though entirely different in the method of compilation, were begun, are now in progress, and will be continued, until sets for all the navigable waters of the globe are completed; and it is a description of these new charts that will constitute the second paper of this article.

THE STUDY OF PHYSIOLOGY.

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BIOLOGY is the science of the structure, the functions, the distribution, and the succession in time of all living beings. If the proper study of mankind be man, he has learned late in the inquiry that he can only understand himself by recognizing that he is but one in the vast network of organic creation; that intelligible human anatomy must be based upon comparative anatomy; that human physiology can only be approached as a branch of general physiology, and that even the humblest mold or sea-weed may furnish help to explain the most important problems of human existence.

The branch of physiology which is concerned with man, not as an individual, but a family, the branch which we now call Anthropology, is obviously related to practical politics, and it was not without reason that the late illustrious pathologist Rokitansky began a speech in the Upper House of the Austrian Parliament on the autonomy of the Bohemian nation with the words, "The question really is, whether the doctrine of Darwin be true or no."

In another department, that of psychology, the physiology of the nervous system has already thrown more light upon the mysterious phenomena of consciousness than was gained by the acutest minds of all ages without the help of anatomical methods.

All the improvements of modern agriculture and stock-breeding rest upon more or less fully understood scientific principles, and the more perfectly the results have been first worked out in the laboratory the more safe and the more lucrative will be their application in the field.*

Still more important is the relation of physiology to the national health. The commonplaces of hygiene which are now, one may be

* I need only refer to the fruitful labors of Mr. Lawes and Dr. Gilbert in this direction.

thankful to say, taught, if not practiced, in almost every schoolroom and factory in England, are the direct results of the abstruse researches of Boyle and Priestley, of Lavoisier and Pasteur. Ages of experience did not teach mankind the value of fresh air, or the innocence of clean water. Indeed, I have myself heard astonishment expressed by a German professor at the peculiar immunity with which English skins will bear the daily and unstinted application of soap and water.

If the art of keeping a community in health is but the application of plain physiological laws, it is no less true that the art of restoring the health, curative as distinct from preventive medicine, rests upon the same basis. In former days the physician was one who recognized what he called the disease of his patient, who referred to his books of precedents as a lawyer to his statutes, and who prescribed a proper remedy to cast out the disease. We now know that disease is, as the name implies, a purely subjective conception. The disease of a host is the health of the parasite, and we cure a human sufferer by poisoning the animals or plants which interfere with his comfort. The same changes which in the old man are the natural steps of decay, the absence of which after a certain age would be truly pathological, are the cause of acute disease in the young. Pathology has no laws distinct from those of physiology.

When these now obvious considerations are thoroughly understood, it clearly follows that all "systems of medicine" are in their very nature condemned. All that the art of medicine can do is to apply a knowledge of natural laws, of mechanics and of hydrostatics, of botany and zoölogy, of chemistry and electricity, of the behavior of living cells and organs when subjected to the influence of heat and of cold, of acids and alkalies, of alcohols and ethers, of narcotics and stimulants, so as to modify certain deviations from ordinary structure and function which are productive of pain, or discomfort, or death. It is, therefore, plain that rational medicine, or keeping right and setting right the human body, must rest upon a knowledge of its structure and its actions, just as a steam-engine or a watch can not be mended upon general principles, but only by one who is familiar with their construction and working, and who can detect the source of their irregularity.

An objector may say: "Admitting that medicine is an art, it is a purely empirical art. You can not detect the origin of many of the maladies which you are yet able to cure; your best remedies have not been obtained by scientific experiment, but by chance, observation, and accumulated experience; and, if you doctors would give more time to practical therapeutics, that is, to finding out what is good for the several aches and pains we complain of, you would spend your time better than in abstruse researches into microscopic anatomy or the properties of a dead frog's muscle."

The answer to the objection is an appeal to fact. For centuries so-called observation and experience left medicine in the condition it occupied at the end of the seventeenth century. The progress of therapeutics is to be marked, not by the labors of "practical men" (who, by the way, are of all the most theoretical, only that their theories are wrong), but by the, at first sight, unconnected studies of Descartes and Newton, of Hooke and Grew, of Lavoisier and Davy and Volta, of Marshall Hall and Johannes Müller.

The history of science proves that unconnected, unsystematic, inaccurate observations are worth nothing. For untold ages men have had ample opportunities of studying the indications of the weather, and have felt the utmost desire to obtain a knowledge of what they portend. Yet it may fairly be said that nothing had been done to the purpose until combined and systematic observations were made in this country and America. The fact is, that popular notions do not rest upon experience or observation. They rest, with scarcely an exception, upon metaphysical theories. In dealing with uneducated persons, both of the lower and higher ranks, physicians find abundance of theories as to the nature and the origin of disease, and of suggestions as to its cure. The only thing which would be of value is what we can scarcely ever get—an accurate observation of what they see and feel. Every fallacy of popular medicine, every solemn medical imposture, is the ghost of some long defunct doctrine of the schools. Therefore it is that common experience is almost absolutely useless in practical arts. They, without exception, depend for their progress upon the advance of science—that is, upon methodical, continuous, and scrupulously accurate observations and experiments.

Many important advances in the practice of medicine have been gained by direct and intentional experiments instituted with a therapeutical object. Such was the Hunterian operation for aneurism, the process of skin-grafting, and subperiosteal operations; such was the administration of chloroform and the introduction of nitrite of amyl, chloral hydrate, and carbolic acid. Such direct experiments still go on, and among them deserve mention, for the skill and the untiring patience with which they were carried out, those investigations upon the action of various drugs on the secretion of bile for which we are indebted to Professor Rutherford and his coadjutors. Even apparently accidental discoveries were not made accidentally. Hundreds of country surgeons must have been familiar with the cow-pox, and have seen examples of the immunity it conferred from the more terrible variola, but he who discovered vaccination was no falsely-called practical man. He was a man of science, the friend of Hunter and of Cavendish, an anatomist and natural philosopher. The fruits of Jenner's discovery are spread over the whole earth. This humble village doctor has saved more lives than the most glorious conqueror destroyed, but his name is little honored, and the only monument to his memory has been banished from association with vulgar kings and skillful homicides to an obscure corner of the great city where his only homage is the health and beauty of the children who play around his statue.

But, after all, it is not so much by direct and immediate contributions to the art of healing that Physiology has vindicated her ancient title of the institutes of medicine, numerous and important as these contributions have been. It is still more by the scientific spirit which has transformed the empty learning so justly ridiculed by Molière and Le Sage into the practical efficiency of modern surgery. Let me give an instance of what I mean. The notion of measuring the temperature of the body is simple enough, and the rough observation that in inflammation the temperature is raised had led to the various terms by which it was denoted in ancient medicine, and to numberless theories now happily forgotten. But although the thermometer was well known, and had been applied by many scientific physicians, notably by De Haen, by Dr. John Davy, and by Sir Benjamin Brodie, yet the practical value of the clinical thermometer which now every practitioner carries in his pocket was not understood until the other day. Those only who had been trained in accurate physical and physiological investigations, who had learned the worse than uselessness of "rough observation," were able to see the enormous importance of clinical thermometry. This most practical of modern improvements in medicine would never have been dreamed of by "practical men"; we owe it to the scientific training of German laboratories.

If physiology is of such great national importance, if the necessity of experimental research is so vital to the common national wealth, to agriculture and commerce, to health and well-being, ought not its well-ascertained results to be taught in our common schools, and its prosecution directly encouraged by the state?

There is no question of the great importance of children being taught the rudimentary laws of health, the bodily evils of dirt and sloth and vice, the excellence of temperance, the danger of the first inroads of disease. Such teaching, now broadcast in many excellent manuals, as "The Personal Care of Health," by the late Dr. Parkes, and Dr. Bridges's "Catechism of Health," is no doubt extremely valuable, and happily is daily more and more diffused. But when beyond the direct utility of such knowledge we attempt to make it an intellectual discipline, there are, I conceive, difficulties which will always prevent even elementary physiology from forming an important part of general education. First, there is the practical difficulty of the necessary dissections; next, the impossibility of making physiology demonstrative; and, thirdly, the abstruseness of the subject. It is impossible to have even an elementary knowledge of the laws of living beings without a very considerable familiarity with those of physics and of chemistry, and even in medical schools it requires all our efforts to prevent it degenerating into a mere dogmatic statement of results, or a labored repetition of hearsay statements. As an intellectual discipline, for facility of demonstration, for the simplicity of the objects, their beauty and interest, their associations with the green lanes and broad moors of England, with the poetry of "Cymbeline" and "Lycidas," with fairy tales and local folk-lore—botany is to my mind the branch of natural science which is above all others to be chosen where one only can be taught. Next in importance I would place elementary physics, the knowledge of the simplest laws of masses at rest and in motion, of heat and light. Its great recommendations are its precision, its constant and useful illustrations in daily life, the interest it gives to the handicrafts and manufactures in which so large a number of English boys and girls are busied, and the necessity of such knowledge as the first step in acquiring all other natural sciences.

First, then, I would that every Sheffield girl should love flowers with the deep and abiding affection of familiar knowledge, and that every Sheffield lad should know every common plant in your beautiful woods, and find his purest pleasure on the heights of Bell Hagg and the broad expanse of Stanage Moor. And next I would that your workmen and work-boys should know so much of mechanics that they may take an intelligent pride in your vast factories, and that in some of them may be awakened the genius to which we trust to repeat in future generations the national services of Arkwright, and Watt, and Stevenson.

With regard to the endowment of research in biology, I must confess that I should be sorry to see it undertaken by government funds. That such investigations are of public interest, that they are difficult and expensive, and that at present they languish for want of adequate support, is all true. But this country is not so poor, nor our countrymen so wanting in public spirit, that we need appeal to the national purse to supply every ascertained want. Great as is the national importance of science, the nation is more important still; and even if that were the alternative, I would rather that we should indefinitely continue dependent on Germany for our knowledge than give up the local energy, the unofficial zeal which has made England what she is. Far better for the strength and the civilization of the nation that a thousand pounds were raised every year for the endowment of unremunerative researches in this wealthy town of Sheffield than that ten thousand were paid you by a paternal monarch or an enlightened department.

But surely there is no need for us to go to Parliament for such sums as we require. In the first place, scientific men themselves show a good example of not asking before they give. There is the modest sum which we raise in this Association, there are the funds for helping research of the Royal Society, the Chemical Society, the British Medical Association, the Iron and Steel Institute, the Whitworth

Scholarships. Next we have the resources of our universities, which have scarcely begun to apply themselves to the task. I need do no more than allude to the Cavendish Laboratory, or to the Physiological School at Cambridge, where a simple college tutor of rare ability, and of still more rare sympathy and energy, has in ten years achieved results which we need not shrink from comparing with those of the great Continental laboratories. The magnificent Museum of Anatomy, maintained by the College of Surgeons almost entirely out of their own funds, is another instance of private care for science to which we find no parallel abroad; and the Zoölogical Society wisely spends a large part of its income in prosecuting comparative anatomy, and in publishing its beautifully illustrated memoirs.

But besides the efforts of scientific bodies and the wealth of our national universities, we may surely look to the public spirit of ancient companies and corporations to do something for the cause of science. In the middle ages our country was covered with parish churches by private munificence; in the sixteenth century most of our public and grammar schools were endowed; in later times our great religious and charitable societies were founded. May we not hope that, before the close of the present century, the discriminating knowledge which alone prevents gifts of money from being a curse instead of a blessing to a community, may lead to the establishment of libraries, and museums, and laboratories by universities and towns, which shall bear comparison, I will not say with those of Paris, or Leipsic, or Bonn, but with the poorer but scarcely less distinguished schools of Heidelberg and Göttingen, of Würzburg and of Utrecht?

Where we have institutions already under government control and patronage, let them be maintained as efficiently and liberally as possible. The British Museum, and its library, the Royal Observatory at Greenwich, and the Royal Gardens at Kew (happily preserved for the present from the short-sighted eagerness of those who would destroy their scientific value)—these are great national institutions of which we are justly proud. Successive governments will have enough to do to maintain their efficiency and to guard them from incompetent interference.

Whatever may be thought of the duty of the state directly to encourage the pursuit of animal and vegetable physiology, one would have supposed that at least what diplomatists call a benevolent neutrality would be shown to a pursuit so laborious and costly, which demands trained workmen and the devotion of a lifetime, which is so important for the national wealth and health, and which, by reason, by experience, and by testimony, we know to be the only guarantee for advance in the various branches of the healing art. Why is it then that institutions which owe nothing to government assistance, and men who spend their time and talents in self-denying and unremunerative service for the public good, are not suffered to pursue their beneficent work in peace?

You know that certain persons who profess to be shocked by the methods of physiological research have succeeded in placing this branch of science under as great disabilities as that sense of humor would allow which so often redeems British ignorance from its most mischievous results.

The method that has given rise to so much excitement is the performance of experiments upon living animals. Now, if this were injurious to the greatest good of the greatest number of the community, or if freedom to perform these experiments interfered with the freedom of other persons to abstain from them, or if such experiments were forbidden by any religious or moral authority, by the ten commandments, or by Mr. Matthew Arnold, of course they must be given up; but, equally of course, the science of physiology must also come to a stop, and the farmer, the cattle-breeder, and the physician must be content with such knowledge or such ignorance as he at present possesses. I know it has been asserted that the science of the functions of living organs is quite independent of experiment upon living organs. But this is said by the same persons who have denied that the art of setting right the functions of the body when they go wrong has anything to do with the knowledge of what those functions are.

If you could be persuaded that chemistry can make progress without retorts and balances, that a geologist's hammer is a useless incumbrance, or that engineers can build bridges just as well by the rule of thumb as by the knowledge gained in a workshop, then you might believe that physiology also is independent of experiment.

It is absurd to object to the difficulties of the research or even the contradictory results sometimes obtained. The functions of a muscle or a gland are more complicated than those of water or gas, and their investigation needs greater skill, more caution, and more frequent repetition. Imperfect experiments can lead to nothing but error; criticism from other physiologists, or from scientific men experienced in other branches of research, is not wanting, and is always welcome. But vague assertion that further progress is impossible by the very means which have led to all our present knowledge, coming from those "who are not of our school," or any school, is undeserving of serious notice.

The real contention, of course, is a moral one, that we ought to relinquish the advantage of all experiments which are accompanied with pain to the creature experimented on. The botanist may serve his plants as he pleases, and even the animal physiologist may cut, or starve, or poison all sentient organisms which happen not to possess a backbone, and he may try experiments with all backboned animals, including himself and his friends, so long as they do not hurt; but that must be the limit. On the most extreme humanitarian views no objection can be made to experiments upon animals in a state of insensibility to pain, and as these constitute, happily, the vast majority of physiological experiments, the question is narrowed to comparatively restricted limits. Is it wrong to inflict painful experiments upon animals for the sake of science? In the absence of any authority to appeal to, we can but judge of the matter by analogy. Now, it has been the practice of all mankind, and is still allowed by the common consent both of law and feeling, that we should destroy by more or less painful means, that we should enslave and force to work, and mutilate by painful operations, and hunt to death, and wound, and lacerate, and torture the brute creation for the following objects: for our own self-preservation, as when we offer a reward for the killing of tigers and snakes in India; for our comfort, as when we poison or otherwise destroy internal parasites, and vermin, and rats, and rabbits. Our safety, our food, our convenience, our wealth, or our amusement—all these objects have been and are regarded by the great mass of mankind, and are held by the laws of every civilized country, to be sufficiently important to justify the infliction of pain or death upon animals in whatever numbers may be necessary. The only restriction which Christian morality or in certain cases recent legislation imposes upon such practices is, that no more pain shall be inflicted than is necessary for the object in view. Killing or hurting domestic animals when moved by passion or by the horrible delight which some depraved natures feel in the act of inflicting pain was until lately the only recognized transgression against the law of England. I trust I need not say that it is only under such restrictions that physiologists desire to work.* Any one who would inflict a single pang beyond what is necessary for a scientific object, or would by carelessness fail to take due care of the animals he has to deal with, would be justly amenable to public reprobation. And remember it is within these limits that the whole controversy lies, for, after a long and patient examination of all that could be said by our accusers, the Royal Commission which was nominated for the purpose unanimously reported that in this country at least scientific experiments upon animals are free from abuse.

What is deliberately asserted is, that within the restrictions which all humane persons impose upon themselves, it is lawful to inflict pain or death upon animals for profit or for sport, for money or for pastime; that property and sport are in England sacred things; but that the practices which they justify are unjustifiable when pursued with the object of increasing human knowledge or of relieving human suffering.

Of those persons who answer that they consider vivisection for the sake of sport to be almost as detestable as vivisection for the sake of duty, I would only ask first that they should deal impartially with

* They are, in fact, the very limits that were put on record by this Association long before the agitation against physiology began. (See Report for 1871, p. 144.)

both offenses, and secondly that since in the one case their opinions are opposed to the practice of genteel society, and in the other to the convictions of all who are qualified to judge, they should at least contemplate the possibility of being mistaken. Putting the question of field sports altogether aside, you know perfectly well that in every village in England an extremely painful mutilation is constantly performed upon domestic animals in no registered laboratory, under no anæsthetics, and with no object but the convenience and profit of the owner. You remember how, when an epidemic threatened the destruction of valuable property, every booby peer now eager to stop, so far as in him lay, the advance of knowledge, was no less eager to have carried out at the public expense any slaughter and any experiments, painful or otherwise, which would save his pocket.

But you will say: All this seems reasonable enough; but if so, how do you account for the prejudice against you; what has induced so many amiable and otherwise sane persons to join in the outcry against physiology?

First, I answer, it is due to the most frequent cause of folly—ignorance. Many persons, supposed to be educated, are so destitute of the most ordinary conceptions of natural science that they do not understand the necessity for experiments. So little do they appreciate the difference between formal knowledge and real knowledge, that a distinguished statesman once assured me that he would as soon have his leg set by a man who had gained what he called his knowledge from books, as by one who had "walked the hospitals." Next, there is the vulgar dislike of whatever is not obviously and immediately useful. When knowledge for its own sake is in question, those of the baser sort are always ready to cry, with equal ignorance of literature and of science, "*Cui bono?*"

In another class of persons, less ignorant and less stupid than these two, opposition to physiological experiments appears to spring from what may fairly be stigmatized as sentiment, that is to say, excitable, rather than deep feeling, uncontrolled by reason. People first gratify their fancy by calling cats and dogs our fellow creatures, which, in one sense, undoubtedly they are, and then, by the familiar fallacy of an ambiguous middle term, argue that it is cruel to put our fellow creatures to pain; or, as some would add, to reduce them to slavery, or to use them in any way for our own, rather than their good. Such persons compel their fellow creatures to drag them through the streets, they eat their fellow creatures when sufficiently vivisected to be palatable, and then find philosophical excuses for those who kill their fellow creatures for fun. But they are properly shocked when their fellow creatures are hurt or killed for the benefit of mankind. Such persons have been accused of feminine weakness; but I must say that I never have found an intelligent woman who could not see the rights of the case when fairly explained to her, whereas I have met a few men who in this, as in other matters, consistently refuse to give up to argument the notions which were formed by prejudice.

This sentiment is, I admit, the degradation of just feeling. To many unaffectedly compassionate hearts there is a peculiar pang in thinking of suffering which is deliberately inflicted, with only the justification of duty, instead of the excuse of ignorance or passion. They see in the helplessness of the dumb animals an appeal for pity, almost like that of childhood, and are justly indignant with the selfish cruelty so often exercised upon them. All honor to the efforts which have banished so many cruel sports from England; all honor to the society which seeks to prevent cruelty to animals! If it can point to any additional means by which the sufferings of animals in the cause of science can be diminished, we shall be anxious to adopt them. If it can point to any abuse in one of our laboratories, we will hasten to correct it. This society has honorably declared that they know of none. That physiologists have been heedless, or even callous, in their experiments upon animals in past times, when men were strangely insensible even to human suffering, or in countries where a healthy result of Christian civilization has not yet been seen in habitual gentleness to animals, I need not deny. Such cases have been eagerly sought and sometimes most unfairly judged. Only lately a learned body felt itself not strong enough to retain the admittedly invaluable services of an eminent foreigner, who had once admitted that when absorbed in scientific and beneficent researches he lost sight of any pain that might be inflicted.* Is not this the very excuse which is held valid in the case of sport? Doubtless we ought to be ever mindful of every branch of duty, but such occasional forgetfulness does not show hardness of heart. It is an excusable weakness for a student of medicine to shudder or to faint at the sight of blood, but he learns that this merely physical sensibility becomes selfish and mischievous if indulged: he is taught to suppress all such exhibition of emotion, and to let it stimulate without paralyzing his efforts to relieve. But no one surely would think the hysterical youth more truly humane than the surgeon whose compassion is shown in the very firmness with which he inflicts a temporary pain for an ultimate good.

I have hitherto rested the whole argument upon the lawfulness of inflicting pain and death upon the lower animals for the sake of science and humanity, but as a matter of fact I may again assure those who, while assenting to the justice of the plea, yet shrink from what it may involve, that the great majority of experiments upon animals are rendered painless, and that the remainder are mostly those experiments which are most immediately and directly subservient to medical art,

* Fortunately, Dr. Klein, whose researches in microscopic anatomy and pathology are so well known and appreciated, knows that he retains the confidence and respect of his scientific brethren, and we hope that his honorable connection with the largest school of medicine in London will strengthen other and closer ties in binding him to England.

and happily even these are generally productive rather of discomfort than of pain. Let me give you an example of such a vivisection, far more painful than the immense majority of those of the laboratory. Suppose a country surgeon were sent for late at night to some case of urgent peril; knowing that his ride is for life or death, and unsparing of himself or his horse, he rides him to the utmost limits of endurance, and beyond: who would not applaud the action? Those only who appear deliberately to believe that our life is worth less than that of many sparrows, those legislators only who look forward to the time when wars will cease, not because of human slaughter, of devastated homes, of all the horrors which the world has endured for centuries, but because of the cruelties to which the horses in the artillery are subjected. We, who are familiar with human suffering and sorrow, which our knowledge is all too feeble to prevent, best understand how, in testing some new remedy on a less precious fellow creature than a man, one who is truly humane may be tempted to forget the comparatively trivial suffering of a rabbit or a frog.

But some enthusiastic opponent will say: "I can not pretend to doubt that these experiments are in every sense of the word useful; but we ought not to purchase the benefit they confer by inflicting pain upon innocent creatures. I would sign a petition to-morrow to put down all field sports by law, I would allow no operation upon domestic animals, and I will abstain from all animal food until I am certain that I can eat creatures which have been killed without suffering pain. But if I were lying at the point of death, and you brought an animal to my bedside and assured me that by putting it to pain my life would be saved, I would refuse to purchase it on such cruel terms." We may hope that the excellent person who made this heroic profession would, in the hour of trial, be better advised, but if not we may surely reply: "Right reverend sir, you are the best judge of the value of your own life, and, if you think proper to sacrifice it to the comfort of a Guinea-pig, we must submit to the loss with such resignation as we can muster; but when you say that in obedience to this silly whim you will let your dearest friend suffer, allow the sacrifice of the most important life, and forbid those studies which have already rescued multitudes from deformity and misery and death, then those of us who have to do with the real responsibilities of life, and on whom presses the awful sense of impotence to which our defective science too often leaves us, answer that we too have duties to fulfill, and to the best of our power we mean conscientiously to fulfill them."

There is, I fear, another reason which animates much of the opposition to physiological experiments. It is nothing else than aversion from the methods and the results of science. It may be that an excuse for this dislike has been furnished by the pretense of false science, and the arrogance of much even which is true. But surely no reasonable creature, from such trivial irritation, can deliberately wish to check the progress of accurate knowledge by observation and experiment. There are, indeed, some who, fearing (as I think prudently) that, "while a little philosophy inclineth men to atheism, depth in philosophy bringeth men's minds about to religion," and desiring to subject the human mind to a bondage as hard and more degrading than that of mediæval Rome, would gladly call off interest from the unremunerative labors which are prompted only by the thirst for knowledge and faith in the possibility of learning more and more of the divine order of the world, to pursuits which bring obvious and material utility. There are those again who, fearing (as I think foolishly) that increasing knowledge of this divine order will lower our admiration of its beauty, or that the better a man understands the laws of God the more likely he is to break them, have an unfeigned dislike for natural science in general, and for biology in particular. They repeat over again the error of which the Dominican friars, with far greater excuse, were guilty when they imprisoned Galileo. If any such are here, may I venture to tell them—in quietness and in confidence is your strength: the vast fabric of Christian morals is in no danger of being overturned by the discovery of a new chemical method in the laboratory, or of a hitherto undescribed animalcule. If noisy attacks are made in the injured name of science, you have only to wait, and you will see these attacks repelled by the true leaders of science themselves, or, at the worst, by the next generation. But if, leaving your secure fortress of defense, you come down with your rhetoric and your sentiments, your *petitio principii*, your *ignoratio elenchi*, and all your familiar fallacies and tropes, thinking that with such weapons you can meet, on their own ground, men who have spent their lives in the study of science, then no wonder if you suffer grievous defeat. Happy for you if you learn, like another discomfited pilgrim, to betake yourselves to another "weapon."

But I imagine that some of my audience are saying: "This defense would have been necessary before the Royal Commission made their report; but when that was made, and affirmed the necessity of physiological experiments, and the groundlessness of accusations of cruelty against physiologists, when an act was passed which licenses physiological laboratories, under the very restrictions which you had already imposed upon yourselves, may we not regard the controversy as closed, and the result as satisfactory?"

I answer that I have taken up your time with this defense of physiological experiments partly because I would fain help, however feebly, in the enlightenment of the public conscience, but also because the result of recent legislation is *not* satisfactory.

Science does not work readily in fetters. A system of licenses and certificates, numerous and complicated, obtained with trouble and delay, and revocable at the will of a minister who may, by the accidents of party, be at any time amenable to anti-scientific influences, such a system adds serious difficulties to those already in the way of experiments.

Suppose, as an illustration, that certain persons opposed on various grounds to learning, and especially hostile to Greek, had attacked the study of Plato. They would point out the danger of modern ladies becoming as well read in his writings as was Lady Jane Grey. They would show that the laxity of modern manners was coincident with the popularity of the "Symposium," and that the notorious increase of infanticide was the result of the teaching of the "Republic." Associations for the total suppression of Plato would be formed, with hired advocates, and anonymous letters, and "leaflets," spreading a knowledge of his most objectionable passages. Scholars would be threatened with eternal punishment, and schoolmasters with the withdrawal of their pupils. Then a royal commission would be appointed—a great Latin scholar, a Whig, and a Tory statesman (who, having taken a B. Sc. degree at Oxford would be impartially ignorant of Greek), the most intelligent despiser of Plato who could be found, the master of a grammar-school on the modern side, and (perhaps the most efficient of all) a lawyer, who knew nothing about Greek, but hated cant. This commission would take evidence that the Platonic writings were not all immoral, that they had been quoted with approval by Fathers of the Church, that they were of great importance to literature and philosophy, and even to the elucidation of the Sacred Writings. It would also be proved that the Platonic dialogues were far less immoral than multitudes of other widely circulated books, or than a French novel which one of the royal commissioners happened to be reading; and, lastly, that the morals of Greek scholars, and of clergymen who had read Plato at college, were not obviously degraded below those of other people. On the other hand, witnesses would depose that a knowledge of Plato was of no consequence to a student of philosophy; that, if it were, the text was in so corrupt a condition that no two scholars agreed as to a single chapter, and that, after all, philosophy was of no practical use, least of all to clergymen. Others would affirm that, though they had never read a line of him, they knew that his style was as vicious as his sentiments; and perhaps some cross-grained scholar might be found who, having once edited a play of Euripides, would declare that all studies in Greek literature ought to be restricted to the tragedians, and that for his part he had never opened any other authors and had never felt the want of them.

At last the commission would report that there was no question of the value of the works of Plato, that it would be mischievous and impracticable to prohibit their study, and that there was no evidence that schoolmasters habitually chose the least edifying passages as lessons for boys. Then what is called a compromise would be made. It would be enacted that Plato might be read, but only in colleges annually licensed for that purpose; that every one wishing to read must have a general certificate signed by certain professors, and setting forth his object, also to be renewed every year; and that special certificates might be severally obtained for reading certain excepted dialogues, for copying from them, for publishing them, or, in rare cases, for translating them.

However reasonably such a system might be administered, who can doubt the result would be a diminution of the number of scholars, and a check to the progress of learning?

Now this is what legislation has done for physiological experiments. The act (39 and 40 Victoria) was hastily drawn and hurriedly discussed; for noble lords and honorable gentlemen who had been taught from childhood to vivisect for unscientific purposes were eager to hurry off to their own merry vivisections, for which they were ready provided with license and certificates. And it works as might be expected. Some shrink from seeing their names figure in disreputable newspapers, and receiving more or less savagely abusive anonymous letters. Others have no laboratories, and find difficulty in licensing their houses. Others are refused the certificates they require.

In one case two thoroughly qualified men were anxious to carry out an important investigation on the treatment of snake-bites. They procured venomous snakes from a distance, and applied for the special certificates necessary. Considerable delay ensued; various objections were raised, and set at rest; and at last all the certificates were obtained; but meantime the snakes had died.

MYTHOLOGIC PHILOSOPHY.*

By Major J. W. POWELL.

II.

IV.—Outgrowths from Mythologic Philosophy.

THE three stages of mythologic philosophy that are still extant in the world must be more thoroughly characterized, and the course of their evolution indicated. But in order to do this clearly, certain outgrowths from mythologic philosophy must be explained, certain theories and practices that necessarily result from this philosophy, and that are intricately woven into the institutions of mankind.

Ancientism.—The first I denominate ancientism. Yesterday was better than to-day. The ancients were wiser than we. This belief in a better day and a better people in the elder time is almost universal among mankind. A belief so widely spread, so profoundly enter-

* An Address delivered before the American Association for the Advancement of Science, at Saratoga, New York, August 29, 1879, by Major J. W. Powell, Vice-President of Section B.

tained, must have for its origin some important facts in the constitution or history of mankind. Let us see what they are.

In the history of every individual, the sports and joys of childhood are compared and contrasted with the toils and pains of old age. Greatly protracted life, in savagery and barbarism, is not a boon to be craved. In that stage of society where the days and the years go by with little or no provision for a time other than that which is passing, the old must go down to the grave through poverty and suffering. In that stage of culture to-morrow's bread is not certain, and to-day's bread is often scarce. In civilization, plenty and poverty live side by side ; the palace and the hovel are on the same landscape ; the rich and poor elbow each other on the same street : but, in savagery, plenty and poverty come with recurring days to the same man, and the tribe is rich to-day and poor to-morrow, and the days of want come in every man's history, and when they come the old suffer most, and the burden of old age is oppressive. In youth, activity is joy ; in old age, activity is pain. No wonder, then, that old age loves youth, or that to-day loves yesterday, for the instinct is born of the inherited experiences of mankind.

But there is yet another and more potent reason for ancientism. That tale is the most wonderful that has been most repeated, for the breath of speech is the fertilizer of story. Hence, the older the story, the greater its thaumaturgics. Thus, yesterday is greater than to-day by natural processes of human exaggeration. Again, that is held to be most certain, and hence most sacred, which has been most often affirmed. A Brahman was carrying a goat to the altar. Three thieves would steal it. So they placed themselves at intervals along the way by which the pious Brahman would travel. When the venerable man came to the first thief he was accosted : "Brahman, why do you carry a dog ?" Now, a dog is an unclean beast which no Brahman must touch. And the Brahman, after looking at his goat, said : "You do err ; this is a goat." And when the old man reached the second thief, again he was accosted : "Brahman, why do you carry a dog ?" So the Brahman put his goat on the ground, and after narrowly scrutinizing it, he said, "Surely this is a goat," and went on his way. When he came to the third thief he was once more accosted : "Brahman, why do you carry a dog ?" Then the Brahman having thrice heard that his goat was a dog, was convinced, and throwing it down, he fled to the temple for ablution, and the thieves had a feast.

The child learns not for himself, but is taught, and accepts as true that which is told, and a propensity to believe the affirmed is implanted in his mind. In every society some are wise and some are foolish, and the wise are revered, and their affirmations are accepted. Thus, the few lead the multitude in knowledge, and the propensity to believe the affirmed started in childhood is increased in manhood in the great average of persons constituting society, and these propensities are inherited from generation to generation, until we have a cumulation of effects.

The propagation of opinions by affirmation, the cultivation of the propensity to believe that which has been affirmed many times, let us call *affirmatization.* If the world's opinions were governed only by the principles of mythologic philosophy, affirmatization would become so powerful that nothing would be believed but the anciently affirmed. Men would come to know new knowledge. Society would stand still listening to the wisdom of the fathers. But the power of affirmatization is steadily undermined by science.

And, still again, the institutions of society conform to its philosophy. The explanation of things always includes the origin of human institutions. So the welfare of society is based on philosophy, and the venerable sayings which constitute philosophy are thus held as sacred. So ancientism is developed from accumulated life-experiences; by the growth of story in repeated narration; by the steadily increasing power of affirmatization, and by respect for the authority upon which the institutions of society are based; all accumulating as they come down the generations. That we do thus inherit effects we know, for has it not been affirmed in the Book that "the fathers have eaten grapes, and the children's teeth are set on edge"? As men come to believe that the "long ago" was better than the "now," and the dead were better than the living, then philosophy must necessarily include a theory of degeneracy, which is a part of ancientism.

Theistic Society.—Again, the actors in mythologic philosophy are personages, and we always find them organized in societies. The social organization of mythology is always found to be essentially identical with the social organization of the people who entertain the philosophy. The gods are husbands and wives, and parents and children, and the gods have an organized government. This gives us theistic society, and we can not properly characterize a theism without taking its mythic society into consideration.

Spiritism.—In the earliest stages of society of which we have practical knowledge by acquaintance with the people themselves, a belief in the existence of spirits prevails—a shade, an immaterial existence, which is the duplicate of the material personage. The genesis of this belief is complex. The workings of the human mind during periods of unconsciousness lead to opinions that are enforced by many physical phenomena.

First, we have the activities of the mind during sleep, when the man seems to go out from himself, to converse with his friends, to witness strange scenes, and to have many wonderful experiences. Thus the man seems to have lived an eventful life, when his body was, in fact, quiescent and unconscious. Memories of scenes and activities in former days, and the inherited memories of scenes witnessed and actions performed by ancestors, are blended in strange confusion by broken and inverted sequences. Now and then the dream-scenes are enacted in real life, and the infrequent coincidence or apparent verification makes deep impression on the mind, while unfulfilled dreams are forgotten. Thus the dreams of sleepers are attributed to their immaterial duplicates—their spirits. In many diseases, also, the mind seems to wander, to see sights, and to hear sounds, and to have many wonderful experiences, while the body itself is apparently unconscious. Sometimes on restored health, the person may recall these wonderful experiences, and during their occurrence the subject talks to unseen persons, and seems to have replies and to act, to those who witness, in such a manner that a second self—a spirit independent of the body—is suggested. When disease amounts to long-continued insanity, all of these effects are greatly exaggerated, and make a deep impression upon all who witness the phenomena. Thus the hallucinations of fever-racked brains, and mad minds, are attributed to spirits.

The same conditions of apparent severance of mind and body witnessed in dreams and hallucinations are often produced artificially in the practice of *ecstacism.* In the vicissitudes of savage life, while little or no provision is made for the future, there are times when the savage resorts to almost anything at hand as a means of subsistence, and thus all plants and all parts of plants, seed, fruit, flowers, leaves, bark, roots—anything in times of extreme want—may be used as food. But experience soon teaches the various effects upon the human system which are produced by the several vegetable substances with which he meets, and thus the effect of narcotics is early discovered, and the savage in the practice of his religion oftentimes resorts to these native drugs for the purpose of producing an ecstatic state under which divination may be performed. The practice of ecstacism is universal in the lower stages of culture. In times of great anxiety, every savage and barbarian seeks to know of the future. Through all the earlier generations of mankind, ecstacism has been practiced, and civilized man has thus an inherited appetite for narcotics to which the enormous propensity to drunkenness existing in all nations bears witness. When the great actor in his personation of Rip Van Winkle holds his goblet aloft and says, "Here's to your health and to your family's, and may they live long and prosper," he connects the act of drinking with a prayer, and unconsciously demonstrates the origin of the use of stimulants. It may be that when the jolly companion has become a loathsome sot, and his mind is ablaze with the fire of drink, and he sees uncouth beasts in horrid presence, that inherited memories haunt him with visions of the beast-gods worshiped by his ancestors at the very time when the appetite for stimulants was created. But ecstacism is produced in other ways, and for this purpose the savage and barbarian often resorts to fasting and bodily torture. In many ways he produces the wonderful state, and the visions of ecstasy are interpreted as the evidence of spirits.

Many physical phenomena serve to confirm this opinion. It is very late in philosophy when shadows are referred to the interception of the rays of the sun. In savagery and barbarism shadows are supposed to be emanations from or duplicates of the bodies causing the shadows. And what savage understands the reflection of the rays of the sun by which images are produced? They also are supposed to be emanations or duplications of the object reflected. No savage or barbarian could understand that the waves of the air are turned back and sound is duplicated in an echo. He knows not that there is an atmosphere, and to him the echo is the voice of an unseen personage—a spirit. There is no theory more profoundly implanted in early mankind than that of spiritism.

Thaumaturgics.—The gods of mythologic philosophies are created to account for the wonders of nature. Necessarily they are a wonder-working folk, and having been endowed with these magical powers in all the histories given in mythic tales of their doings on the earth, we find them performing most wonderful feats. They can transform themselves; they can disappear and reappear; all their senses are magical; some are endowed with a multiplicity of eyes, others have a multiplicity of ears; in Norse mythology the watchman on the rainbow bridge could hear the grass grow and the wool on the backs of sheep; arms can stretch out to grasp the distance, tails can coil about mountains, and all powers become magical. But the most wonderful power with which the gods are endowed is the power of will, for we find that they can think their arrows to the hearts of their enemies; mountains are overthrown by thought, and thoughts are projected into other minds. Such are the thaumaturgics of mythologic philosophy.

Mythic Tales.—Early man having created through the development of his philosophy a host of personages, these gods must have a history. A part of that history, and the most important part to us as students of philosophy, is created in the very act of creating the gods themselves. I mean that portion of their history which relates to the operations of nature, for the gods were created to account for those things. But to this is added much else of adventure. The gods love as men love, and go in quest of mates. The gods hate as men hate, and fight in single combat or engage in mythic battles; and the history of these adventures impelled by love and hate, and all other passions and purposes with which men are endowed, all woven into a complex tissue with their doings in carrying out the operations of nature, constitutes the web and woof of mythology.

Religion.—Again, as human welfare is deeply involved in the operations of nature, man's chief interest is in the gods. In this interest religion originates. Man, impelled by his own volition, guided by his own purposes, aspires to a greater happiness, and endeavor follows endeavor, but at every step his progress is impeded: his own powers fail before the greater powers of nature; his powers are pygmies, nature's powers are giants, and to him these giants are gods with wills and purposes of their own, and he sees that man in his weakness can succeed only by allying himself with the gods. Hence, impelled by this philosophy, man must have communion with the gods, and in this communion he must influence them to work for himself. Hence, religion, which has to do with the relations which exist between the gods and man, is the legitimate offspring of mythologic philosophy.

Thus we see that out of mythologic philosophy, as branches of the great tree itself, there grow ancientism, theistic society, spiritism, thaumaturgics, mythic tales, and religion.

V.—The Evolution of Mythologic Philosophy.

I shall now give a summary characterization of zoötheism, then call attention to some of the relics of hecastotheism found therein, and proceed with a brief statement of the higher stages of theism. The apparent and easily accessible is studied first. In botany, the trees and the conspicuous flowering plants of garden, field, and plain were first known, and then all other plants were vaguely grouped as weeds; but, since the most conspicuous phenogamous plants were first studied, what vast numbers of new orders, new genera, and new species have been discovered, in the progress of research, to the lowest cryptogams!

In the study of ethnology, we first recognized the more civilized races. The Aryan, Hamites, Shemites, and Chinese, and the rest were the weeds of humanity—the barbarian and savage, sometimes called Turanians. But, when we come carefully to study these lower people, what numbers of races are discovered! In North America alone we have more than seventy-five—seventy-five stocks of people speaking seventy-five stocks of language, and some single stocks embracing many distinct languages and dialects. The languages of the Algonquin family are as diverse as the Indo-European tongues. So are the languages of the Dakota, the Numa, the Tinné, and others; so that in North America we have more than five hundred languages spoken to-day. Each linguistic stock is found to have a philosophy of its own, and each stock as many branches of philosophy as it has languages and dialects. North America presents a magnificent field for the study of savage and barbaric philosophies.

This vast region of thought has been explored only by a few adventurous travelers in the world of science. No thorough survey of any part has been made. Yet the general outlines of North American philosophy are known, but the exact positions, the details, are all yet to be filled in—as the geography of the general outline of North America is known by exploration, but the exact positions and details of topography are yet to be filled in as the result of careful survey. Myths of the Algonquin stock are found in many a volume of *Americana*, the best of which were recorded by the early missionaries who came from Europe, though we find some of them, mixed with turbid speculations, in the writings of Schoolcraft. Many of the myths of the Indians of the South, in that region stretching back from the great Gulf, are known—some collected by travelers, others by educated Indians.

Many of the myths of the Iroquois are known. The best of these are in the writings of Morgan, America's greatest anthropologist. Missionaries, travelers, and linguists have given us a great store of the myths of the Dakota stock. Many myths of the Tinné also have been collected. Petitot has recorded a number of those found at the North, and we have in manuscript some of the myths of a Southern branch—the Navajos. Perhaps the myths of the Numas have been collected more thoroughly than those of any other stock. These are yet unpublished. Powers has recorded many of the myths of various stocks in California, and the old Spanish writings give us a fair collection of the Nahuatl myths of Mexico, and Rink has presented us an interesting volume on the mythology of the Innuits; and, finally, fragments of mythology have been collected from nearly all the tribes of North America, and they are scattered through thousands of volumes, so that the literature is vast. The brief description which I shall give of zoötheism is founded on a study of the materials which I have thus indicated.

All these tribes are found in the higher stages of savagery, or the lower stages of barbarism, and their mythologies are found to be zoötheistic among the lowest, physitheistic among the highest, and a great number of tribes are found in a transition state, for zoötheism is found to be a characteristic of savagery, and physitheism of barbarism, using the terms as they have been defined by Morgan. The supreme gods of this stage are animals. The savage is intimately associated with animals. "From them he obtains the larger part of his clothing, and much of his food, and he carefully studies their habits and finds many wonderful things. Their knowledge and skill and power appear to him to be superior to his own. He sees the mountain-sheep fleet among the crags, the eagle soaring in the heavens, the humming-bird poised over its blossom-cup of nectar, the serpents swift without legs, the salmon scaling the rapids, the spider weaving its gossamer web, the ant building a play-house mountain—in all animal nature he sees things too wonderful for him, and from admiration he grows to adoration, and the animals become his gods." *

Ancientism plays an important part in this zoötheism. It is not the animals of to-day whom the Indians worship, but their progenitors—their prototypes. The wolf of to-day is a howling pest, but that wolf's ancestor—the first of the line—was a god. The individuals of every species are supposed to have descended from an ancient being—

* *Vide* "Outlines of the Philosophy of the North American Indians," by J. W. Powell. Read before the American Geographical Society at Chickering Hall, December 29, 1876.

a progenitor of the race; and so they have a grizzly-bear-god, an eagle-god, a rattlesnake-god, a trout-god, a spider-god—a god for every species and variety of animal.

By these animal-gods all things were established. The heavenly bodies were created and their ways appointed, and when the powers and phenomena of nature are personified, the personages are beasts, and all human institutions also were established by the ancient animal-gods.

The ancient animals of any philosophy of this stage are found to constitute a clan or *gens*—a body of relatives, or *consanguinii*, with grandfathers, fathers, sons, and brothers. In Ute theism, the ancient Togoav, the first rattlesnake, is the grandfather, and all the animal-gods are assigned to their relationships. Grandfather Togoav, the wise, was the chief of the council, but Shinauav, the ancient wolf, was the chief of the clan.

There were many other clans and tribes of ancient gods with whom these supreme gods had dealings, of which hereafter; and, finally, each of these ancient gods became the progenitor of a new tribe, so that we have a tribe of bears, a tribe of eagles, a tribe of rattlesnakes, a tribe of spiders, and many other tribes, as we have tribes of Utes, tribes of Sioux, tribes of Navajos: and in that philosophy tribes of animals are considered to be coördinate with tribes of men. All of these gods have invisible duplicates—spirits—and they have often visited the earth. All of the wonderful things seen in nature are done by the animal-gods. That elder life was a magic life; but the descendants of the gods are degenerate. Now and then as a medicine-man by practicing sorcery can perform great feats, so now and then there is a medicine-bear, a medicine-wolf, or a medicine-snake that can work magic.

On winter nights, the Indians gather about the camp-fire, and then the doings of the gods are recounted in many a mythic tale. I have heard the venerable and impassioned orator on the camp-meeting stand rehearse the story of the crucifixion, and have seen the thousands gathered there weep in contemplation of the story of divine suffering, and heard their shouts roll down the forest aisles as they gave vent to their joy at the contemplation of redemption. But the scene was not a whit more dramatic than another I have witnessed in an evergreen forest of the Rocky Mountain region, where a tribe was gathered under the great pines, and the temple of light from the blazing fire was walled by the darkness of midnight, and in the midst of the temple stood the wise old man telling in simple savage language the story of Tawats, when he conquered the sun and established the seasons and the days. In that pre-Columbian time, before the advent of white men, all the Indian tribes of North America gathered on winter nights by the shores of the seas where the tides beat in solemn rhythm, by the shores of the great lakes, where the waves dashed against frozen beaches, and by the banks of the rivers flowing ever in solemn mystery—each in its own temple of illumined space—and listened to the story of its own supreme gods, the ancients of time.

Religion, in this stage of theism, is sorcery. Incantation, dancing, fasting, bodily torture, and ecstacism are practiced. Every tribe has its potion or vegetable drug, by which the ecstatic state is produced, and their venerable medicine-men see visions and dream dreams. No enterprise is undertaken without consulting the gods, and no evil impends but they seek to propitiate the gods. All daily life, to the minutest particular, is religious. This stage of religion is characterized by fetichism. Every Indian is provided with his charm or fetich, revealed to him in some awful hour of ecstasy produced by fasting, or feasting, or drunkenness, and that fetich he carries with him to bring good luck, in love or in combat, in the hunt or on the journey. He carries a fetich suspended to his neck, he ties a fetich to his bow, he buries a fetich under his tent, he places a fetich under his pillow of wild-cat skins, he prays to his fetich, he praises it, or chides it; if successful, his fetich receives the glory; if he fail, his fetich is disgraced. These fetiches may be fragments of bone or shell, the tips of the tails of animals, the claws of birds or beasts, perhaps dried hearts of little warblers, shards of beetles, leaves powdered and held in bags, or crystals from the rocks—anything curious may become a fetich. Fetichism, then, is a religious means, not a philosophic or mythologic state. Such are the supreme gods of the savage, and such the institutions which belong to their theism. But they have many other inferior gods. Mountains, hills, valleys, and great rocks have their own special deities—invisible spirits—and lakes, rivers, and springs are the homes of spirits. But all these have animal forms when in proper *personæ*. Yet some of the medicine-spirits can transform themselves, and work magic as do medicine-men. The heavenly bodies are either created personages or ancient men or animals translated to the sky. And, last, we find that ancestors are worshiped as gods.

Among all the tribes of North America, with which we are acquainted, tutelarism prevails. Every tribe and every clan has its own protecting god, and every individual has his "my god." It is a curious fact that every Indian seeks to conceal the knowledge of his "my god" from all other persons, for he fears that, if his enemy should know of his tutelar deity, he might by extraordinary magic succeed in estranging him, and be able to compass his destruction through his own god.

In this summary characterization of zoötheism, I have necessarily systematized my statements. This, of course, could not be done by the savage himself. He could give you its particulars, but could not group those particulars in any logical way. He does not recognize any system, but talks indiscriminately, now of one, now of another god, and with him the whole theory as a system is vague and shadowy, but its particulars are vividly before his mind, and the certainty with which he entertains his opinions leaves no room to doubt his sincerity.

But there is yet another phase of theism discovered. Sometimes a particular mountain, or hill, or some great rock, some waterfall, some lake, or some spring receives special worship, and is itself believed to be a deity. This seems to be a relic of hecastotheism. Fetichism, also, seems to have come from that lower grade, and all the minor deities, the spirits of mountains and hills and forests, seem to have been derived from that same stage, but with this development, that the things themselves are not worshiped, but their essential spirits.

From zoötheism, as described, to physitheism the way is long. Gradually, in the progress of philosophy, animal-gods are dethroned and become inferior gods or are forgotten; and gradually the gods of the firmament—the sun, the moon, the stars—are advanced to supremacy: the clouds, the storms, the winds, day and night, dawn and gloaming, the sky, the earth, the sea, and all the various phases of nature perceived by the barbaric mind, are personified and deified and exalted to a supremacy coördinate with the firmament gods; and all the gods of the lower stage that remain—animals, demons, and all men—belong to inferior tribes. The gods of the sky—the shining ones, those that soar on bright wings, those that are clothed in gorgeous colors, those that came from we know not where, those that vanish to the unknown—are the supreme gods. We always find these gods organized in great tribes, with mighty chieftains who fight in great combats or lead their hosts in battle, and return with much booty. Such is the theism of ancient Mexico, such the theism of the Northland, and such the theism discovered among the ancient Aryans.

From this stage to psychotheism the way is long, for evolution is slow. Gradually men come to differentiate more carefully between good and evil, and the ethic character of their gods becomes the subject of consideration, and the good gods grow in virtue, and the bad gods grow in vice. Their identity with physical objects and phenomena is gradually lost. The different phases or conditions of the same object or phenomenon are severed, and each is personified. The bad gods are banished to underground homes, or live in concealment, from which they issue on their expeditions of evil. Still, all powers exist in these gods, and all things were established by them. With the growth of their moral qualities no physical powers are lost, and the spirits of the physical bodies and phenomena become demons, subordinate to the great gods who preside over nature and human institutions.

We find, also, that these superior gods are organized in societies. I have said the Norse mythology was in a transition state from physitheism to psychotheism. The Asas, or gods, lived in Asgard, a mythic communal village, with its Thing or Council, the very counterpart of the communal village of Iceland. Olympus was a Greek city.

Still further in the study of mythologic philosophy we see that more and more supremacy falls into the hands of the few, until monotheism is established on the plan of the empire. Then all of the inferior deities whose characters are pure become ministering angels, and the inferior deities whose characters are evil become devils, and the differentiation of good and evil is perfected in the gulf between heaven and hell. In all this time from zoötheism to monotheism, ancientism becomes more ancient, and the times and dynasties are multiplied. Spiritism is more clearly defined, and spirits become eternal ; mythologic tales are codified, and sacred books are written ; divination for the result of amorous intrigue has become the prophecy of immortality, and thaumaturgics is formulated as the omnipotent, the omnipresent, and the infinite.

Time has failed me to tell of the evolution of idolatry from fetichism, priestcraft from sorcery, and of their overthrow by the doctrines that were uttered by that voice on the Mount. Religion, that was fetichism and ecstacism and sorcery, is now the yearning for something better, something purer, and the means by which this highest state for humanity may be reached, the ideal worship of the highest monotheism, is "in spirit and in truth." The steps are long from Shinauav, the ancient of wolves, by Zeus, the ancient of skies, to Jehovah, the "ancient of days."

Comparative theology furnishes grand illustrations of the processes of evolution. It presents a multiplicity of events occurring in orderly succession in obedience to the laws of adaptation, heredity, and survival of the fittest, and, in passing from the lower to the higher state, it demonstrates the fundamental law of progress, that evolution is from the homogeneous to the heterogeneous by successive differentiations and integrations.

THE EVOLUTION OF A NEW SENSE.

By WILLIAM A. EDDY.

WE find that the degrees of perception in people vary. In other words, one may receive more impressions than another, so that we measure the extent of a person's life by the number of objects or ideas that produce a lasting effect and modify the disposition or mental tendency. This suggests a comparison of the senses in different persons. Then arises the general question of the possible evolution of new powers, for with a wider meaning we may term the telegraph, the printing-press, and particularly the telescope, approximations to what we may consider new senses. The subject may be thus carried to the higher point concerning the increase of all the mental powers.

In "our little life . . . rounded with a sleep," we are cut off by invisible barriers from even a comprehension of the peculiar tastes for enjoyment manifested by some others. It is difficult to understand Livingston's contentment during a life of exile and exposure. There was in him an inextinguishable mental tendency which appeared in his strange delight in conquering difficulties. But we need not cite an example from the other hemisphere. We see this bias or mental momentum (if a mechanical phrase be allowable in affairs of the mind) all around us. It is true the force is not always effective, but this does not invalidate the reality of this peculiar tendency, which too often shows in how singularly narrow a manner the mental powers act. The minds of men are like circles which allow elongation in a given direction, but at the expense of another part of the circle which contracts in a corresponding degree. The addition of a sixth sense would result in a resource which would not lessen the effectiveness of other faculties by a withdrawal of force to supply the new demand.

That we are mentally inadequate appears in our ever-recurring errors. This narrowness of view is also illustrated by the misunderstandings that arise between ideal and practical men. Some persons who are devoted exclusively to every-day affairs can not easily comprehend how others can look at a printed page and then form imaginary images or be greatly interested in fiction. On the other hand, the imaginative reader is forced to admit the importance of practical people, yet he can not see why they take pleasure in trade, which to the reader of intense literary taste involves necessary monotony—like that of a mill at which tramps in England were forced to grind before they could obtain lodging. The ideal and the practical are apparently at opposite poles, yet the general result conforms to the law of liquids in hydraulics : a proper balance is maintained in spite of particular variations. But this intense progressive action, or bias, on one side or the other, should be distinguished from the primary power which would be added were another subjective connection opened with the objective world. The perceptions of a new sense would be positive, like those of our present senses, and would in no manner seem the result of effort or of the skill that comes by practice.

Mr. Gladstone, in an article contributed to the "Nineteenth Century," tried to demonstrate theoretically that the perception of color among the ancients was especially defective. In support of this he cited numerous passages from Homer as showing that the great Greek poet could not distinguish fine shades of color. After noticing Homer's comparison of the objects in nature with the colors of animals, he argues that a person with the average modern eye for the perception of color would not have made such comparisons without being aware of their inaccuracy. But he does not maintain that everybody in Homer's time was color-blind. He simply quotes many passages from Greek literature as supporting his position that, we will say, where one person is color-blind now, nine were color-blind then. Looked at hastily, this question of color seems of small importance. But let us look carefully. Is it not startling to think that the primary senses may be widening? It would follow, if additional evidence should be found to sustain Mr. Gladstone's theory, that the highly civilized portions of the human race are capable of perceiving finer shades of color, owing to a more delicate material development of the sense of sight. Once admit the development of one of the senses to be a demonstrated process, and the door is opened to tremendous consequences and possibilities of power, and consequently to a wider scope for the soul in the coming generations of men. For comprehension of the methods of Nature inevitably results in that form of control which opens the way to further perceptions.

In some respects the development of the senses is not quite as inconceivable as it may at first appear. The following analogies can hardly be considered sufficiently connected by evidence to be properly called theories, yet they are only relatively visionary. For example, imagine that we should acquire the power to become aware of the smallest change of material particles many miles away. Tait and Stewart have ingeniously argued that, according to the law of attraction, the slightest vibration or change of particles in the human brain during thought infinitesimally influences the remotest fixed star. This does not appear wildly theoretical, because it is mathematically demonstrable to the imagination. The visionary theory is in supposing that owing to corresponding vibrations of nerve-fiber we would be definitely conscious of distant material changes. This would result in a form of universal consciousness and consequent confusion, unless the perception were specialized in the form of a concentrated effort. The singular analogy is that the effect arising from the mutually attractive vibrations of particles would resemble the process by which sound reaches us—an accordance of the vibration of the ear-drum with that of the air. George Henry Lewes has shown that "the physiologist can lawfully speak of unconscious sensations as the physicist can speak of invisible rays of light—meaning those rays which are of a different order of undulation from the visible rays, and which may become visible when the susceptibility of the retina is exalted." This is in part applicable to Mr. Gladstone's theory of the development of the perception of color. It is believed that the heat-rays of the sun, largely consisting of what are called the dark rays, do not produce a luminous effect, simply because the vibrations of the nerve-substance of the retina are not in unison with the invisible ray. In the same way the perception of color may involve a special series of vibrations absent in color-blind persons. Then arises the question here noticed, as to whether the sensation of color is owing to individual education, or is the result of slow and continuous physiological evolution during thousands of years. Owing to lack of evidence the question seems at present unanswerable. But it is obvious that our present senses might reveal more to us, because we are inferior to many animals in detecting objects by smell, hearing, or sight. Our comparative dullness is apparently due to the fact that there is with us no incessantly impending danger, and in consequence some of these senses are not as often excited.

It is unquestionably our wish that we could have greater powers of discernment. The telegraph and printing-press are indications of this longing for a wider life. Science has taught us that we perceive only an infinitesimal part of the objective world and of its processes. The theoretical addition of another sense does not satisfy us. It would seem only a new working-wheel of the mechanism. In fact, greatly magnified powers of perception without the assistance of instruments seem possible only through slow methods of development. If a sixth sense should confer upon us with our present range of faculties the power to be everywhere at once, we would be reduced to a state of confusion equivalent to the nullification of consciousness. The attempt to conceive it results in absurd contradictions. It is precisely this condition of omnipresence which is vaguely imagined as possible in clairvoyance. One of the difficulties in regard to accepting clairvoyance as an indication of a sixth sense is that the effect arises from a diseased condition of the sensibility. The result is unaccountable, but at the same time unwholesome. It is at variance with the steadily increasing scientific knowledge of our day in the fact that its phenomena evade verification or reduction to a consistent law of action. Men have been learning for the past five thousand years or more that physical or mental work and obedience to natural law increase the force and effectiveness of the individual and of his descendants. The geological discoveries of Huxley and Marsh, and the development of the simplest forms of vegetable life, denote an irresistible evolutionary sequence or working power in nature. It seems as necessary that those animals with the greatest power of adaptation should survive and express the later result, as that, to use Spinoza's geometrical illustration, the sum of the angles of a triangle should equal two right angles. And it is probable that a finer and higher grade of perceptions would not be altogether through the physiological development of our present senses, because such senses imply an inevitable relation or result from the action of the outer world; but many such perceptions would be due to a greater command of material potencies—such as that outlined in the possible extension of knowledge through the telephone, the phonograph, or the liquefaction of all the gases.

Among the many singular and original ideas attributed to Edgar A. Poe, was one to the effect that during a silence of about twenty minutes it is possible to know an intimate friend's line of thought as well as if the ideas had taken form in words. In order to be successful, this would require a very intimate acquaintance with the friend's habits of thought. In fact, we all try to interpret the thoughts of others during silence, but we are generally wide of the mark, because we do not know the peculiar law of association of ideas applicable to each person. There is a general process by which one idea suggests another in all minds, but there are also particular variations. Nevertheless, unless the person is on his guard, fully seventy-five per cent. of his ideas will be known to any one who is accustomed to following the thoughts of others. The first thoughts, which arise in the mind automatically, are limited in number, because the connection with more remote ideas has not yet been made. It is probable that with increased knowledge of the peculiar laws of mental action, great skill will be shown in thus following the ideas of others, and it is clear that such a science of mind-reading would be built upon metaphysical data, just as mathematical data are now necessary factors in estimating the distance and motion of a planet. In some respects the limit of mental penetration may not be as absolute as we imagine. It is certainly not advisable to set limits like those astronomers who claimed that they had discovered the center around which the visible universe is revolving in a mighty orbit. It was found that this so-called center was describing a vast arc of a circle around another center inconceivably distant. The discoveries of the past indicate that others as important are to be made. The horizon recedes, revealing new objects.

In the light of past discoveries it seems highly improbable that so important a physiological gift as a sixth sense could come to us suddenly and mysteriously. This is not the manner in which Nature works. Everything is paid for, and our advantages come only from work and its accompanying natural growth, or by the hereditary transmission of a fortunate balance of powers in a line of ancestors. The first impulse arises from the necessity of work, and from the actions of events which stimulate the ingenuity. The increased activity is accompanied by an increase of fiber or power of continuance. Tyndall has admirably illustrated the fact that this law of mental supply and demand applies with precision to the processes of nature: "No particle of vapor was formed and lifted without being paid for in solar heat. There is nothing gratuitous in physical nature, no gain without equivalent expenditure." It is our tendency to look for theatrical or imposing manifestations of human power not paid for by work, and when a result appears mysterious owing to our ignorance of its source, we too often settle the difficulty in accordance with a convenient and visionary theory. In this way we hear a coincidence called a prophetic dream. No one has adequately estimated the enormous number of dreams that drift through the mind during a lifetime, and when a dream coincides in a measure with an event which takes place long afterward, the assumption then is that some dreams are of a prophetic nature. It seems clear that the only element of prophecy is due to a coincidence or similarity between the dream and the event. The minute particulars missing from the dream will be filled in by the imagination almost unconsciously, because the events of the dream and the real events become confused in the recollection.

All this does not divest the unknown of its mysterious possibilities. But there is a striking contrast between the so-called unaccountable results of clairvoyance and mesmerism, in their relation to transcendental knowledge, and the theories of science founded upon verified experiments. The obscurity or apparent mystery of the scientific theory steadily decreases with each addition of evidence, until the astonishing possibility "hardens into a fact." The clairvoyant theory not only evades all attempts to analyze it, but utterly fails in regard to any valuable results which could serve as starting-points for future discovery. The coming fact at once seems "reasonable and real," and does not rest upon the mere belief of one person. It can be verified from more than one point of view, and carries with it the convincing force of an axiom. Emerson, in his lecture in the Old South Church, Boston, on February 24, 1878, finely said, "The gracious lesson taught by science to this country is, that the history of nature from first to last is incessant advance from less to more, from rude to finer organization, the globe of matter thus conspiring with the principle of undying hope in man."

We must look to the onward march of progressive development for new power, and not to the mysterious and so far valueless results of clairvoyance, with its examples of trickery or nervous organisms thrown out of balance. There is more of the spiritual element in a beautiful sunset than in the table-rapping and other dramatic effects of animal magnetism or jugglery.

WHY DO SPRINGS AND WELLS OVERFLOW?

By NELSON W. GREEN.

SINCE water tends to find a level, we infer that flowing water is acting in harmony with this natural law, unless it be put in motion by some equivalent force. The overflowing of wells and springs has hitherto been accounted for by scientists only upon the supposed existence of hydrostatic pressure. But a more careful investigation seems to justify the conclusion that, while in exceptional cases this may occur, yet as a proposition it is fallacious, and it will be the aim of the following discussion to expose the fallacy.

In 1844 Rev. William Buckland, Professor of Geology at Oxford, England, was invited, on account of his learning and character, to give an address, in which he made the following statements:* "Wells sunk to a greater depth through stratified rocks often afford large supplies, but rarely rise to the surface; and in cases where they do so they are called artesian wells, from the circumstance of such artificial flowing wells being common in Artois (France). In all these cases [among which the Professor included the flowing wells at Grenelle, near Paris] the water was forced up by hydrostatic pressure to various distances from the surface. At Brentford, England, there were many wells that continually overflowed their orifice, which is a few feet only above the Thames. In the London wells the water rises to a less level than in those at Brentford."

By hydrostatic pressure, the Professor, of course, means a head, i. e., that the water flowed to these wells from a higher point. If this rise were due to hydrostatic pressure, why did the water rise to a lower level at London than at Brentford among the hills? Professor Buckland continues: "In November, 1840, notice was given of an application to Parliament to obtain a new supply of water for London from wells and water-works to be made at Wetford in the chalk-hills. A company had been proposed to effect this object, which would probably have been carried out, had not Mr. Clutterbuck demonstrated, by a long-continued series of measurements of the water in the chalk-hills of Hertfordshire, near Wetford, that every drop of water taken from that neighborhood would have been abstracted from the summer and autumn supplies of the river Coln and would have robbed the proprietors of more than thirty mills upon this river and its tributaries, and the owners of adjacent water-meadows, of rights they had had from time immemorial. One intelligent manufacturer, Mr. Dickinson, had, during many years, found arithmetical evidence that the quantity of summer water in the river Coln varied with the rain in the preceding winter. He could always tell, at the end of February or March, what water there would be in the following eight or nine months; and he regulated the contracts he made in every spring, for paper to be delivered in the summer and autumn, by the quantity of water in his winter rain-gauge. This rain-gauge, the invention of Dalton, being buried three feet below the surface, showed that except in December, January, and February, rain-water rarely descended more than three feet below the soil, so as to add anything to the supply that sinks into the earth to issue during summer, and from springs and rivers; and, whenever Mr. Dickinson found by this instrument that but little rain had fallen in the three months of winter, he proportionally limited his contracts for the following summer and autumn, thus proving the practical advantage of inductions from philosophy."

The following abstract from Professor Buckland's speech may also be in order: "As persons who have no experience in these subjects

* Copied into vol. iii., p. 70, of "Littell's Living Age," from the "Edinburgh Journal."

may be surprised at the knowledge geologists profess to have acquired respecting the internal structure of the earth, he (the Professor) would endeavor to confirm the above theoretical explanation of the origin and supply of springs by appealing to practical proofs in the proceedings of water companies and well-diggers, and in the pounds, shillings, and pence in the ledgers of manufacturers." It certainly must be a matter of "surprise" to most people that, while the rain-water rarely sank deeper than three feet into the soil, it could yet influence the water-supply to be drawn from deep wells in the earth, so much as to draw upon the water-supply of the river Coln, which like that of all rivers is more or less dependent upon surface influences in addition to overflowing springs. Wells to supply London, the Professor thinks, must not be utilized to draw water from a depth of thirty or forty feet because it would cut off the supply due to the rains which do not sink deeper than three feet! It should have been the easiest possible thing to supply London without in any way drawing upon the supply of the river Coln, since the river and the wells draw from different sources. The learned Professor had no idea of the existence of any force in the premises other than hydrostatic pressure, and yet he proceeds in the next paragraph to give important evidence of some other force:

"In Germany, Mr. Buckmann, of Heilbronn, published in 1835 an octavo volume on artesian wells in the valley of the Necker, from which it appeared that there were manufactures in Wurtemberg near Constadt where the mills were kept in work during the severest cold of winter by means of the warm water from artesian wells which overflowed into the mill-ponds and prevented them from freezing. And at Heilbronn, also, there were persons who saved the expense of fuel by conducting artesian warm water in pipes through their houses and greenhouses. . . . Let those who doubt go to Grenelle and see the majestic column of warm water from the philosophically discovered fountain rising thirty feet above the surface, at the exact temperature foretold by Arago, and learn the correctness and value of practical deductions from geology applied to the useful purposes of life."

From which quotations it appears that the Professor is in a remarkable position. At Wetford these wells could not be utilized because the river-supply of the Coln would be exhausted; but in Germany they were a new and important source of supply to the rivers themselves. Imagine the "majestic column" at Grenelle rising thirty feet high and the overflow in the other cases being due to hydrostatic pressure—i. e., due to the fact that all these immense floods were the result of a flow from some other higher bodies of water. Why did it not occur to Professor Buckland that, however high and abundant the source, such drains must of necessity have sooner or later exhausted the supply, if no equivalent streams were flowing into that also? But suppose this to be so, whence could come the higher head to flow into and supply that in turn? Carry this on until a flow is secured from the highest land on the earth, and then whence comes the flow to supply that? The mere statement of the case proves the existence of some force in nature other than hydrostatic pressure by which these vast bodies of water are driven to the surface. This hydrostatic pressure Professor Buckland thus illustrates and explains: "The portions of a water-logged, porous bed between two beds of clay may be illustrated by a tea-saucer placed within another tea-saucer, and having the narrow space between filled with sand and water. If a hole were drilled through the bottom of the upper saucer and a quill or small pipe fixed vertically in the hole, water would rise in the pipe to the level at which it stands within the margin of the lower saucer, its rise being caused by the same hydrostatic pressure that raised the water in the well at Southampton, coming from subterranean sheets of the fluid which exists in the fissured chalk-beds of the Hampshire basin, as they do also in the chalk under the basin of London."

Should these exceptional and assumed conditions occur in nature, the result would be substantially as indicated; but, as will be seen at a glance, the flow from a well sunk under such circumstances would be limited to the amount of water between the two saucers, and this will be limited to the quantity of rainfall. Since flowing wells and springs are seldom if ever thus limited, we infer that the case supposed does not occur. But whether it does or not is of no importance, since it in no sense satisfies the conditions of the "majestic column" at Grenelle, and other cases where the flow is perpetual. We must, therefore, look for some other force to explain this class of phenomena. Professor Faraday followed Professor Buckland's lead six years later. M. Garnier, the celebrated French engineer, whose essay in 1822 upon this subject took the governmental prize, also takes this position; as does Dr. Halley. This theory we combat not merely from speculative motives, but in the interest of public health.

Various other theories have been advanced besides hydrostatic pressure. Aristotle and Seneca suggested the central heat of the earth. This theory has been more fully and scientifically stated by E. S. Chapin, in his work on gravity. But this is not the force that we seek. It is inadequate, as the following simple experiment shows: If a moderately flowing spring is surrounded by an air-tight inclosure which shall contract, and terminate in a tube, and this tube be allowed to have a discharge some distance below the surface of the water in the spring before its inclosure, it will be found that the water-flow from the spring has been greatly increased, though no change of temperature has occurred. Again, it has been suggested that the overflow of springs was due to capillary action; but this can hardly need a serious consideration in view of the amount and character of those overflows.

There are three classes of water to be taken into account in this discussion: 1. The surface waters mainly influenced by rainfalls; 2.

Subterranean waters, seldom if ever influenced by rains; 3. A class of waters coming from both of these sources. This discussion relates mainly to the second class. But what are the facts as to the flow of water in this class? Arago says of the well at Grenelle, 1,800 feet deep, "The water to supply it may have come from 40, 80, or 100 miles." There is a "large and important spring called Pales's Hole which issues permanently in quantities sufficient to run a mill at Otterbourne (England). . . . Springs of fresh water often rise even from fissures at the bottom of the sea, and one near Chittagong was 100 miles distant from the land." "The artesian well at Tours rose with a jet that sustained a cannon." "Chautauqua Lake rests like a jewel in the crown of a high mountain-ridge. The basin is shallow, with not more than 80 feet of water at the deepest points, and an average depth of about 20 feet. The surrounding hills are low, 100 to 150 feet higher than the water. Viewed from the hills near Jamestown, four miles distant, the lake has the appearance of being lifted up above its shores; you seem to be looking up to a 'hanging lake,' and you wonder the whole concern does not fall over into some of the valleys close around it. It is a wonder to the unpracticed observer where the water-supply of Chautauqua Lake comes from. The lake nearly fills its own valley. There is not a live stream emptying into it, save one, and that would run through a six-inch pipe. Of course, it is supported like a weary sleeper by the springs in its bed. These must be innumerable to maintain a body of water 20 miles long and two miles wide. Where the water is shallow you can plainly see these springs bubbling up from the bottom of the lake. Their warmth cuts the ice out in large spots in winter at points where they are most numerous. You see floating in the lake tufts of water-grass, which have been uprooted from the bottom by these under-currents."—("New York Semi-Weekly Tribune," August 2, 1878.)

This lake is on the highest land in the State, west of the Catskill Mountains, and yet it is but a vast overflowing spring from which issues a large mill-stream. To account for this large flow from the top of this elevated region by supposing it to fall from some other higher elevation is absurd, since there is no such higher ground from which it could flow without being exhausted. The whole mountain-region of northern Pennsylvania may be referred to as another good illustration of high springs. At every step the traveler notices abundant streams of the purest water, gushing sometimes from the very tops of mountains, and it is in these thickly clustering springs that the great rivers of that wild labyrinth of high ridges and deep valleys find their abundant sources. Within sight of the main road which crosses the summit dividing the waters of the Alleghany River from those running into the Genesee is to be seen a cluster of abundant streams which unite and cross the highway—a noisy torrent—rejoicing in being among the head-waters of the latter river, and the brightest product of overflowing springs. No possible head to this overflow could exist; and, in general, this class of springs flowing out of the mountain-tops can not be materially influenced by the rainfall. There is no land above them from which such torrents could flow in such constant abundance. The White and Adirondack Mountains are also full of similar cases.

"Scribner's Monthly" (vol. xi., p. 784) has a very interesting article by Martin A. Howell, Jr., entitled "Is there a Subterranean Outlet to the Upper Lake Region?" While we are sorry to quarrel with Mr. Howell as to his conclusions, we are very happy to accept his facts. He speculates upon the premise that, because "an area of some 400,000 square miles is drained by the tributaries of Lake Winnipeg alone," a certain amount of this accumulation of waters which do not find an exit "toward the Polar Sea and through the Mississippi Valley" may pass by subterranean channels into Lakes Superior and Huron; and he says that "while Lakes Superior and Huron are supplied largely through such subterranean channels on the one hand, they suffer severely through losses by similar channels at some point in their vast expanse." He shows by a map the track of this supposed underground current to be down the valley of the Illinois from Lake Superior to the valley of the Mississippi. The facts he gives tend strongly to support his novel theory of underground flow southward from the lakes, however it may be as to the amount of it. He gives no evidence that it comes from the direction of Lake Winnipeg, but, on the contrary, the balance of his evidence goes to prove that the Northern lakes are nothing more or less than great, overflowing springs. "That there exist channels of communication with some of these lakes," Mr. Howell says, "has long been believed and admitted by many"; and then, having shown that Lake Superior at its surface is 600 feet above the Atlantic and at its bottom 573, and Ontario to be 235 feet above, with the same depth as Superior, he proceeds to make the following significant statement, which is not at all conclusive as to the intercommunication between the lakes, but is unanswerable as proof that these lakes are overflowing springs:

"And that a great subterranean influx into the upper lakes exists there is little doubt, as a comparison of the discharge through the mighty St. Lawrence with the limited supply from the country bordering on the upper lakes clearly demonstrates, leaving the problem to be settled in the mind as to where this volume does come from in its course to the ocean. Again, the discharge through the St. Lawrence is equal to double the volume poured into Ontario through the Niagara, or into Erie through the St. Clair; suggesting that from the shallowness of Lake Erie and the great depth of Superior and Huron a subterranean channel may connect Superior and Huron with Ontario, giving to the latter, through this source, to be discharged by the St. Lawrence, a greater volume than is given through St. Clair. It is also a well-demonstrated fact that the volume of water escaping from the lakes through the mighty St. Lawrence is far greater than the amount discharged from the upper lakes into Ontario by the proper channels—the St. Clair and Niagara; and it is also well settled that the supply of Lake Erie from St. Clair is about equaled by its discharge through the Niagara; showing that it receives from no subterranean source any perceptible surplus of water. And this is generally attributed to its comparative shallowness as compared to the greater depth of Superior, Huron, and Ontario"—from which it follows that the immense difference between the outflow and the inflow of Ontario is due to its greater depth, thus making it a possible deep spring; and that this applies also to the other deep lakes; and that Superior, Huron, and Ontario, and possibly Michigan, are overflowing springs of subterranean water. The conclusion is therefore inevitable that this great overflow must be accounted for upon some other hypothesis than that of hydraulic pressure, since there is no higher land which could furnish an adequate supply. Indeed, if we suppose all the land on the continent which is higher than Lake Superior to be but shells filled with water, the difference between the outflow and inflow of Ontario would exhaust the supply in a short time. But the subterranean supply is known to be constant, and has always been so. But Mr. Howell supposes this vast surplus in Ontario to come through a subterranean channel, connecting it with Superior. And here, again, we must thank Mr. Howell for his facts. The surface of Superior is, he says, 600 feet above the sea, and Ontario but 235 above. Therefore, the difference of level between the two is 365 feet. If this channel exists as supposed, the surfaces of these lakes would find a common level, instead of a difference of 365 feet!

Mr. Howell, in presenting the proof that there is a great underflow from Superior southward under the valley of the Illinois River, says: "And here on this bank of the old Illinois, opposite the junction of the Fox River, are the celebrated Mineral Springs. . . . These waters are somewhat similar to the waters of Saratoga County, New York," which certainly proves that they do not come from Superior, the waters of which are not of this class. The editor of "Scribner's Monthly" naïvely adds this note: "Whether the Great Lakes are the true reservoirs from which our Northern wells, springs, and subterranean streams receive their constant supply of water, is a question of sufficient interest and significance to merit a thoughtful consideration. The data upon which the advocates of this theory found their conclusions are manifold and forcible, and, though there may be breaks in the line of evidence, the facts as now established would seem to favor the views which the author of this paper now proposes to define and defend." While Mr. Howell presents strong evidence of a possible underflow from Superior southward, he has hardly claimed that the general supply of the "Northern wells, springs, and subterranean streams," all comes from the Northern lakes. A hundred facts are at hand which prove the contrary, even in the vicinity of the lakes. Among these are the magnetic wells at Three Rivers and other places in Michigan and other States. Certainly, Chautauqua, in New York, which has been shown to be but a large overflowing spring, does not draw its supply from these lakes, as its surface is many feet above even that of Superior, the highest of the four Northern lakes.

At different times irregular tidal influences have been observed on these lakes, an example of which is given in this news-note printed in the "Springfield Republican," June 26, 1876: "The water in the canal at Sault Ste.-Marie, Michigan, began rising about ten o'clock Friday morning without any apparent cause, and reached a greater height than has been known for many years. Its variation was four feet nine inches in one hour and twenty minutes." All this without apparent cause. Continuous western winds would have been an "apparent cause," but this did not exist. This and other irregular tidal influences on these lakes are in harmony with the supposed internal force for which we seek.

The following is also well authenticated: "Silver Springs, one of Florida's curiosities, is a subterranean river bubbling up into a basin nearly 100 feet deep and an acre in extent, which sends out a stream 60 to 100 feet wide to the Ocklawaha River six miles distant. To this natural inland port run three streams from St. John's, and in the basin the fish and everything on the bottom can be seen through the crystal waters." Here is a case for which no adequate cause recognized by scientists can with certainty account. A singular case occurs on the shore of the Gulf of Mexico, opposite the town of Alvarado. A ridge of sand has formed on the beach by the action of the wind. It is within memory that, before this ridge formation, "a fresh-water spring was known to exist at its northern extremity, which was then but a few feet in height. The spring is there still, though the ridge is twenty feet in height, the water rising to the top of the ridge."

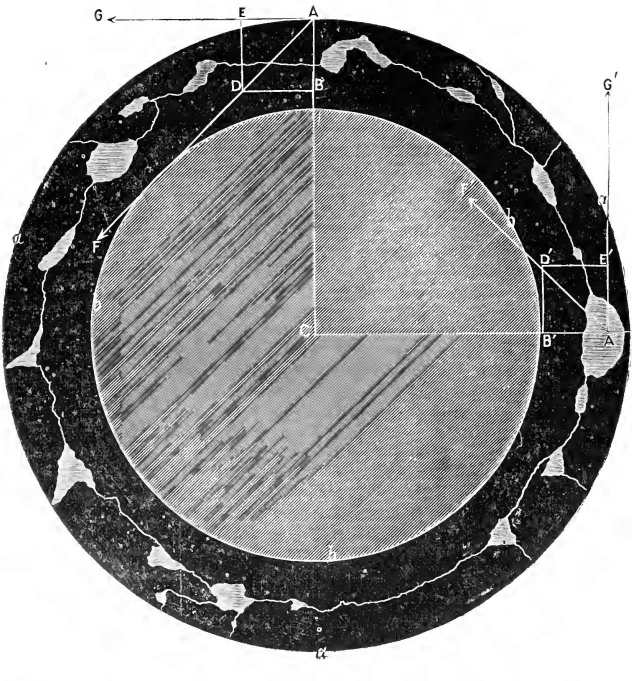
But instances need not be multiplied. The ordinary observer will recall the common fact that the highest land is universally best supplied with flowing springs, and that these overflows can not be accounted for on the supposition of the fall of waters from higher grounds, since such higher grounds do not adequately exist. "The cataract issuing from the Himalayas, or as it is sometimes called Roodroo, is the source of the river Jumna—a rapid and large river; and in fact, many of the largest rivers of the world proceed immediately from mountains and lakes that are formed from cataracts." Thus the Ganges, Nile, Indus, Senegal, Rhine, Rhône, Vistula, Elbe, Loire, Guadiana, Po, Adige, Swale, Tay, Severn, Don, Monongahela, Platte, Missouri, and numerous others have their sources directly in mountains, and many of these "receive no increase from tributary streams, but issue with such astonishing abundance from rocks as to overflow and fertilize the countries through which they pass." This has been more than confirmed by the discoveries of Dr. Livingstone and Mr. Stanley in the heart of Africa, where some of the greatest rivers of the world flow out of the highest part of the African Continent. And in this connection the important element of the rainfall is not ignored. These countries are subject to long and weary droughts. But, while the volume of these great rivers is sensibly affected by the rain and the want of it, they continue to flow within their banks, subject to loss by absorption and evaporation—great and navigable rivers, throughout the longest dry season; and the Nile has no tributaries for five hundred miles of its course.

And, lastly, from the highest mountains in the world—the Himalayas—out of their highest points, great cataracts and streams have poured and still do pour, with an abundance that not only is astonishing, but that would exhaust any possible reservoirs at their extreme tops. Since this is the highest land of the world, no such higher source is possible. Hence the conclusion is inevitable that some force not yet identified exists to which these great overflows are due. It should be remembered that up to this time it is generally held, to use the words of M. Garnier, that "unless there be a reservoir higher than the surface whence we intend to bore, we can not hope to obtain an overflowing fountain." And, as if conscious that there might be some mistake about this theory, he says further that gases may force water up, by which he means to suggest a cause other than hydrostatic pressure. But the experiment which may be seen any day at the gas-works will show that gases do force water down when both are inclosed by a common receiver. There is no conceivable situation in which gases could be expected to force subterranean water in a direction opposed to gravity in such quantities as to satisfy the conditions.

Is it possible, then, to point out any other force in nature which not only may, but which positively must, force waters out of springs at high elevations?

Let *a*, *a*, *a*, be a great circle of the earth attained by passing a plane through the earth's center C, perpendicular to its axis, and *b*, *b*, *b*, the circle cut by the same plane through the inner surface of the earth's supposed crust. In order to obtain room in the figure for illustration, this section is exaggerated. Let the line A B represent the force of gravity, and A E the centrifugal force, at the point A, which will operate in the direction of the tangent A G. These two forces, for the purposes of this discussion, may be assumed to be equal, as the question of their relative intensities does not enter into the problem. Erect upon the line A B the square A B D E, and draw the diagonal A D produced to F. By a well-known law we shall have A D representing the resultant of the forces A B and A E—that is, the line A D will represent the direction A F, and the intensity of the resultant of the force of gravity and the centrifugal force, acting at the point A.

It will be observed that since the diagonal either of a square or of a parallelogram is longer than either of its sides, the resultant, A D, will have a greater intensity than gravity represented by A B. Now, suppose the point A′ to be some point inside the earth's crust, and some



distance from the surface, and suppose also that it is a particle of water in a body of water imprisoned by surrounding rocks. This particle will be acted upon by a continual impulse to move in the direction A′ F′, with an intensity represented by A′ D′. This will be true of every other water-particle in the imprisoned body of water.

If, now, in an hermetically sealed vessel of water a set-screw is turned and pressed upon the water inside until the resistance to it is equal to one pound, that one-pound pressure will be duplicated upon every other equal space of the vessel: and thus, if the end of the screw has one square inch of surface, every square inch of the inside of the vessel will feel a pressure of one pound. Exactly this will occur in the case of the water imprisoned in the rocks. The resultant of the two natural forces, centripetal and centrifugal, will be duplicated upon every point of the inside surface of the supposed rock-prison. The intensity of this resultant will be represented by the aggregation of all the resultants of all the particles of water. Now, suppose a small opening to be made in this rock-prison. Immediately, the water will be forced out with a velocity equal to the influence of these aggregated resultants modified by the laws of friction, and this velocity will not be at all influenced by the direction of the original impulses given to the water-particles. Although the direction of the resultant itself is say 45° from the direction of the force of gravity, its transmitted force will be unimpaired should the opening lead in a direction opposed to gravity, or in fact in any direction, since the tendency of water expansion or reaction under pressure is uniform in all directions. Moreover, since the resultant has been shown to be greater under all circumstances than gravity, certainly the vast aggregations must also be greater than the aggregated gravity, and will be able to overcome it under the conditions stated.

Hence, if fissures exist in rocks that lead to imprisoned waters it would happen that through these outlets the waters must certainly flow; and, if by any artificial means, as by boring, an opening should be made between a body of confined water and the surface of the earth, a flowing well would result.

But, of course, it must be understood that this would not happen if the body of water supposed were an isolated one and completely unconnected with other bodies of water through channels and intercommunications known to exist in the various ramifications of the earth's surface. The subterranean water circulation which interpenetrates the crust of the earth is clearly caused by the centripetal and centrifugal forces of nature, reënforced no doubt often by differences in temperature and other minor causes. And it also might and probably does occur that the overflowing of a well or spring is due to the fact that the water flows from a higher to a lower level, but this will be found to be too rare to form a rule.

The intensity of the centrifugal force will increase with the distance from the center of the earth, while gravity will decrease; the resultant will also increase. Thus, we find the strongest and most abundant overflows at the tops of mountains or on high plateaus. But suppose it had been fully proved that a particular overflowing spring was caused by hydrostatic pressure, it would still remain to be accounted for how the water got to that higher point. This can best be done by the force demonstrated, which is always acting upon the partially confined water-beds and water-channels forming the internal water-structure of the earth's crust. The conditions necessary to the realization of the best results are that these water-deposits shall be more or less imprisoned and the outlets comparatively limited. The overflow will be continued and upward until the resultant is overcome by friction. The lengthening of the channel of overflow, as in the spring at Alvarado, furnishes a corroborating instance of how this law of overflow operates. The spring was originally on the level of the shore until the sand drifted by degrees and formed a ridge twenty feet high, *but the water appeared at the top of the ridge.*

This law can be utilized in increasing the flow of water. As above mentioned, it was found that, by inclosing an overflowing spring tightly and allowing the inclosure to be terminated by a tube with an opening carried to a level below the fountain, the flow was increased because the channel was increased, and the resultant of the natural forces with it.

If an artificial connection be made with a stratum of water or water-bed, as by a tube tightly set in the earth or a series of tubes, and the suction-tube of a pump be attached thereto, we shall have the best conditions for a utilization of this newly discovered force in obtaining water for domestic purposes. The natural channels will thus be continued to the pump, and when this is operated (the air being lifted off) the new force acts as a handmaid in lifting the water. Many experiments fully prove this. As the water-deposits drawn upon are subterranean they are ample for all practical purposes; and, if these facts had been within the knowledge of Professor Buckland and the proposed company to which he has given such prominence, London could have been supplied with pure water without the least occasion for anxiety that the manufactories on the banks of the river Coln would be robbed of their portion.

The force, then, which we have demonstrated may be thus formulated: The resultant of the earth's centripetal and centrifugal forces acts impulsively upon the subterranean water-deposits, and tends to force them into and through the natural channels of the earth's crust.

MARS AND HIS MOONS.

By Professor JOHN LE CONTE,

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THERE is no member of the solar system, with the exception of our moon, which can be studied under such favorable circumstances as the planet Mars; for, although Venus, when in inferior conjunction, is nearer to us than Mars in opposition, yet Venus, at this time, turns her darkened hemisphere toward the earth. Moreover, although Mars does not appear so large an object in the telescope as Jupiter, yet he is in reality seen on a much larger scale, not only on account of his much greater proximity to us, but because, being likewise much nearer the sun, his surface is much more brilliantly illuminated, so that a much higher telescopic power can be advantageously employed. Accordingly, ever since the invention of the telescope, Mars has been a favorite object of observation. The largest and most powerful instruments have been employed to scrutinize this planet, and the varied physical details of its surface have been most carefully mapped by many astronomers.

When, therefore, it was announced two years ago* that the American astronomer, Hall, had discovered two satellites belonging to Mars, we ought not to be surprised at the astonishment with which the news was received by the scientific world. Moreover, there can be no question that for more than two centuries past astronomers have recognized the probability of the existence of satellites to this planet. In fact, analogy would lead us to expect that Mars would be furnished with one or more moons; for, being situated at a greater distance from the sun than the earth, it seems more especially to need such luminaries to cheer its dark nights. Under the influence of these anticipations, the astronomers, who have so carefully studied the physical features of Mars, have doubtless been looking for these satellites. In fact, many of them have contended that the failure to discover them is not by any means a conclusive proof of their non-existence; since, Mars being a very small planet, we might expect his moons to be proportionally small, in which case they might escape detection by the telescope. Thus, for example, the second satellite of Jupiter is only about the forty-second part of the diameter of the planet; and a satellite which would only be the forty-second part of the diameter of Mars would be about one hundred miles in diameter. At the least distance of the earth from Mars a satellite of this dimension would subtend an angle of less than one half of a second; so that, even in the most favorable position of Mars, powerful telescopes might fail to reveal such an object, especially if it do not recede far from the disk of the planet.

Thus, Thomas Dick ("Celestial Scenery," American edition, p. 123, 1838) remarks in relation to this question: "If such a satellite exist, it is highly probable that it will revolve at the nearest possible distance from the planet, in order to afford it the greatest quantity of light; in which case it would never be seen beyond two minutes of a degree from the margin of the planet, and that only in certain favorable positions. If the plane of its orbit lay nearly in a line with our axis of vision, it would frequently be hidden either by the interposition of the body of Mars or by transiting its disk. It is therefore possible, and not at all improbable, that Mars may have a satellite, although it has not yet been discovered. It is no argument for the non-

* It was on the memorable night of the 11th of August, 1877, that Professor Asaph Hall, of the Naval Observatory at Washington, caught the first glimpse of these diminutive companions of Mars. The intervention of unfavorable weather kept him in a state of anxious suspense, and postponed, for a period of five days, the complete verification of his great discovery.

existence of such a body that we have not yet seen it; but it ought to serve as an argument to stimulate us to apply our most powerful instruments to the regions around this planet with more frequency and attention than we have hitherto done, and it is possible that our diligence may be rewarded with the discovery. The long duration of winter in the polar regions of Mars seems to require a moon to cheer them during the long absence of the sun; and, if there be none, the inhabitants of those regions must be in a far more dreary condition than the Laplanders and Greenlanders of our globe."

This state of doubt and uncertainty in relation to the question of the existence of Martial moons afforded legitimate game for the satirical writers of the last century. Thus, Jonathan Swift, in his "Gulliver's Travels," published about 1727, in giving an account of the extraordinary race of abstract philosophers who inhabited the "Floating Island" called Laputa, informs us that "they spend the greater part of their lives in observing the celestial bodies, which they do by the assistance of glasses far excelling ours in goodness; for, although their largest telescopes do not exceed three feet, they magnify much more than those of one hundred with us, and show the stars with greater clearness. This advantage has enabled them to extend their discoveries much farther than our astronomers in Europe; for they have made a catalogue of 10,000 fixed stars, whereas the largest of ours does not contain above one third of that number. They have likewise discovered two lesser stars or satellites, which revolve about Mars; whereof the innermost is distant from the center of the primary planet exactly three of its diameters, and the outermost five; the former revolves in the space of ten hours, and the latter in twenty-one and a half; so that the squares of their periodical times are very near in the same proportion with the cubes of their distances from the center of Mars; which evidently shows them to be governed by the same law of gravitation that influences the other heavenly bodies."

About twenty-five years after Swift wrote the foregoing, that is in 1752, the celebrated Voltaire (apparently in imitation of "Gulliver's Travels") cuttingly ridicules the pretensions of the class of reasoners who found their conclusions upon analogy. In one of his satirical tales, Micromegas, an imaginary inhabitant of Sirius, is supposed to make a voyage of discovery through the solar system in company with a denizen of Saturn; they philosophize as they go. Approaching the planet Mars, Micromegas and his companion plainly descried two moons acting as satellites to that body—moons which have certainly escaped the ken of terrestrial astronomers. "I know perfectly well," continues the author of the tale, "that Father Castel" (an astronomer of the time) "will write, and write sufficiently pleasantly, too, against the existence of these two moons; but I appeal against his decision to logicians, who reason from analogy. These excellent philosophers are perfectly aware how difficult it would be for Mars—a planet so far removed from the sun—to get on with less than two of these satellites." ("Œuvres de Voltaire"—Micromegas, chapter iii.) How completely the recent discovery of the American astronomer has "turned the tables" on the renowned satirist of the last century! The previsions of those "excellent philosophers" who founded their conclusions upon analogical reasoning, although slumbering in the domains of the unproved for more than two centuries, have at last been verified by direct observation.

As the moons of Mars are very small objects, it is only under the most favorable circumstances that they can be seen by the most powerful telescopes. Mars is nearest to us when his opposition occurs, when he is near his perihelion; and the greatest possible proximity to us occurs when Mars is in opposition in perihelion and the earth is in aphelion at the same time. The oppositions of Mars near perihelion occur at intervals of fifteen and seventeen years successively. A very good opposition occurred in 1862, and a great many distinguished astronomers embraced the opportunity of scrutinizing Mars with the aid of excellent instruments. A still more favorable opportunity was presented in the summer of 1877, when Mars was nearer to us than it has been since 1845. It was at this time that Professor Asaph Hall was fortunate enough, by means of the new 26-inch refractor of the Naval Observatory at Washington, to discover two moons belonging to this planet. It is true that this was probably the first time that so powerful a telescope had ever been directed to the examination of Mars under similar favorable conditions; yet it is a significant fact that, since the announcement of the discovery, the satellites have been detected by means of telescopes of more moderate power. The secret of Professor Hall's discovery seems to have consisted in devising the means of cutting off, from the field of view of the telescope, the glaring light of Mars. In like manner, M. Henry, of the Observatory of Paris, on August 27, 1877, was able to see the satellites when Mars was screened from view. These diminutive moons nestle so closely to the planet that it is difficult to see them in the blaze of light reflected from Mars. Had similar means of screening the planet been employed, it is probable that one or both of these satellites might have been discovered in 1862.

The distance of the inner satellite from the center of the primary is about 2·73 times the radius of Mars; that of the outer one about 6·846 times the same radius. Assuming the diameter of Mars to be about 4,200 miles, these distances become, respectively, 5,733 and 14,376 miles from the center of Mars. The nearest satellite of Jupiter is distant about six times the radius of the primary, and the innermost satellite of Saturn is distant a little more than three times the radius of that planet.*

* The following table exhibits the mean distances of the satellites from the centers of the primaries, expressed in equatorial radii of the latter. ("Nature," December 13, 1877, p. 129.)

	Earth.	Mars.	Jupiter.	Saturn.	Uranus.	Neptune.
1..........	60·27	2·72	5·70	2·98	7·71	14·55
2..........	....	6·82	9·07	3·83	10·75	....
3..........	....	....	14·46	4·75	17·63	....
4..........	....	....	25·44	6·08	23·57	....
5..........	....	....	....	8·47	....	....
6..........	....	....	....	19·67	....	....
7..........	....	....	....	24·80	....	....
8..........	....	....	....	57·28	....	....

Professor Newcomb gives, for the period of revolution of the *inner* satellite around Mars, about 7·65 hours, or 7h. 39m., and 30·25 hours, or 30h. 15m., as that of the *outer* moon. Both of them, like our moon, revolve around the primary from west to east. Mars rotates on its axis from west to east in 24·623 hours, or 24h. 37m. 23s.; this is the duration of the Martial day. We have seen that the period of revolution of the *inner* satellite is *less*, while that of the *outer* is *greater*, than a Martial day. It is evident, therefore, that, as seen from the surface of the planet, the *apparent* motion of the satellites will be in opposite directions, the inner rising in the *west* and setting in the east, the outer (like our moon) rising in the *east* and setting in the west. This anomalous condition of things must have greatly perplexed the primitive astronomers of Mars, and probably led them to the invention of cycles and epicycles to account for these appearances.

It follows that the phenomenon of two moons meeting in mid-heavens will be no unusual occurrence to the observers on the surface of Mars. The *apparent* motion of the fixed stars from east to west, produced by the rotation of the planet upon its axis, is at the rate of 14·62° per hour. The *real* motion of the inner satellite among the stars from west to east is at the rate of about 47·06° per hour, while that of the outer one is at the rate of 11·90° per hour. Hence it follows that the *apparent* motion of the inner satellite from *west* to *east* across the heavens, to an observer on Mars, will be at the rate of about 32·44° per hour, while the *apparent* motion of the outer moon from *east* to *west* will be at the rate of nearly 2·72° per hour.

It likewise follows from the preceding calculations that the time elapsing between two successive meridian passages of the inner satellite will be about 11·09 hours, and the time elapsing between two successive conjunctions of the inner with the outer moon will be about 10·24 hours; consequently two conjunctions will occur in less time than it takes for Mars to rotate on its axis, or than a Martial day. This satellite completes more than *three* orbital revolutions in a Martial day.

As the apparent motion of the *outer* satellite from east to west is at the rate of only about 2·72° per hour, it is obvious that the time elapsing between two successive meridian passages of this moon will be about 132·35 hours; so that there will be no less than twelve conjunctions with the inner moon in the course of its lunar day. It is likewise evident that the outer satellite will frequently be above the horizon of Mars more than sixty hours, during which period six conjunctions with the inner may occur. Moreover, as the outer moon will go through its cycle of phases in a little more than thirty hours, all of these changes may be accomplished while it is above the horizon of the observer on the surface of Mars.

The apparent diameter of Mars, as seen by an observer on the inner satellite, would be no less than 41·8°, or about seventy-eight and a half times the apparent diameter of the sun as seen from the earth; and from the outer moon the diameter of Mars would subtend an angle of 16·7°, or about 31·3 times the apparent diameter of the sun as seen by us. Of course the apparent *areas* of the disk of Mars, as seen from his two satellites, would be in the ratio of the *squares* of these numbers, that is, the apparent area of the disk of Mars, as seen from his inner moon, would be 6,167, and from the outer 980 times the apparent area of the solar disk, as seen from the earth.

From the innermost satellite of Saturn, the diameter of the primary would subtend an angle of 35·8°; from the nearest satellite of Jupiter, the diameter of that planet would subtend an angle of 18·6°; and from our moon the earth's diameter would subtend an angle of less than 2°.

Astronomers are, as yet, ignorant of the *real* magnitude of the Martial satellites; but, assuming each of them to be one hundred miles in diameter, it is easy to calculate their apparent magnitudes as seen by an observer on Mars.* The *inner* moon being 5,733 miles distant from the *center* of Mars, would, when in the zenith of the observer, be only 3,633 miles distant from the *surface* of the planet. Hence it appears that, when this satellite is seen in the *horizon* of the observer on the surface of Mars, its diameter would subtend an angle of about 60′, or nearly *twice* the apparent diameter which our moon presents to us; but, when it is in the *zenith* of the observer, it would subtend an angle of 94·3′, or more than *three* times the apparent diameter presented by our moon. In other terms, in rising from the western horizon to the zenith, the apparent diameter of this moon would be increased nearly in the ratio of *two* to *three;* and, of course, its *apparent area* would be augmented nearly in the ratio of *four* to *nine*.

* Professor E. C. Pickering, of the Harvard College Observatory, has attempted to determine the real magnitude of the satellites of Mars, by comparing the *intensity of the light* reflected from the primary with that reflected from each of his satellites. He is thus led to estimate the diameter of the *inner* satellite to be about seven miles, and that of the *outer* one to be about six miles! ("Annual Report of the Director of Harvard College Observatory," November, 1877, page 17.) It is very questionable whether estimates, founded on *photometrical comparisons* in which the *relative reflecting powers* of the bodies compared are *unknown*, can inspire the confidence of astronomers in relation to the *accuracy* of the deduced diameters.

The outer satellite would, under like positions, present apparent diameters, respectively, of 24′ and 28′, or considerably *less* than the apparent diameter of our moon. The nearest satellite of Jupiter (having a diameter of 2,310 miles) would, in like positions, present to an observer on the surface of that planet apparent diameters, respectively, of 31′ and 37′.

As we have seen, the inner satellite of Mars completes *three* orbital revolutions in less than a Martial day. "This anomalous fact in the planetary system would seem, at first view, to be utterly inconsistent with the nebular hypothesis." According to this hypothesis, the *orbital*-periods of the satellites should be approximately equal to the rotation-periods of the primary at the epochs when the satellites were thrown off from it. The acceleration of the rotation-period of the primary, in consequence of its subsequent contraction, would necessarily render its time of rotation *less* than the orbital-period of *any* satellite. As far as yet known, the inner satellite of Mars affords the only instance in which the rotation-period of the primary is *greater* than the orbital-period of the secondary.

It must be remembered, however, that if we regard the rings of Saturn as composed of clouds of independently revolving minute satellites, those constituting the innermost portions of the inner ring must revolve in *less time* than the rotation-period of that planet. Under this view, therefore, the case of the inner satellite of Mars is not *unique*.

There are, however, several methods by which the apparently anomalous fact may be accounted for consistently with the nebular hypothesis:

1. In the first place, it has been suggested that Mars may not have obtained his satellites by means of the usual process of moon-formation, but by the appropriation to himself of a couple of the numerous asteroids or planetoids, some of which, in their perihelion excursions, approach comparatively near to Mars in his aphelion positions. Thus, the planetoid called Phocea, when it is at its *least* distance and Mars at his *greatest* distance from the sun, would only be about 11,000,000 miles from each other. It is, therefore, possible that some of the planetoids, moving in orbits of greater eccentricity than any yet discovered, *may*, at some former period, have approached so near Mars as to have become permanently attached to it as satellites.

2. In the second place, it is possible that these Martial moons may have originally revolved in *larger* orbits, and therefore in *longer* periods than at present, but that the retarding influence of a *resisting medium* on such *small masses* might, in the course of myriads of ages, have *contracted* their orbits and consequently *shortened* their orbital-periods. In this connection it must be borne in mind that, according to the nebular hypothesis, Mars must be a vastly *older* planet than the earth; so that this retardation may have been in progress for an

incalculable number of centuries before the earth became a separate planet.

Until quite recently, it was generally conceded that *two* comets of short period have revealed the existence of a *resisting medium* in the celestial spaces. It is well known that the celebrated Encke inferred the existence of a resisting medium from the fact that the *periodic times* of the comet which bears his name were *progressively diminishing.*

Thus he found the following values of these times :

1786–1795,	periodic	time	= 1208·112	days.
1795–1805,	"	"	= 1207·879	"
1805–1819,	"	"	= 1207·424	"
1845–1855,	"	"	= 1205·250	"

In this view he was sustained by Olbers and most contemporary astronomers, although Bessel and some others dissented from it. But Encke continued steadfast in his theory of a resisting medium in space for more than forty years ; in fact, up to the period of his death in 1865.

There are two *other* periodical comets which were expected to furnish important evidence on this question. These are Faye's and Winnecke's comets, which have periods of seven and a half and five and a half years respectively. The orbit of the former has been carefully determined by Professor Axel Möller, of Lund, Sweden. At first his calculations indicated that the period of this comet was shortened at each revolution by about seventeen hours ; and Encke, in his declining years, thought that this fact was a *complete proof* of his hypothesis of a resisting medium. But, in 1865, Professor Möller revised his calculations, and found that it was possible to harmonize all of the facts *without* the assumption of the resisting medium.

With regard to Winnecke's comet, it seems that, according to the computations of Professor Oppolzer, of Vienna, it is scarcely necessary to call in the assistance of a resisting medium to account for its motions. It thus appears that, up to the present time, Encke's comet stands *alone* in demanding the existence of a resisting medium to explain its motions. Nevertheless, it must be recollected that such investigations involve the computing of complex planetary perturbations, and that, consequently, more accurate data and better mathematical methods may, in the future, place these two comets in the same category, in relation to a resisting medium, as that of Encke.

In the mean time, divers physical considerations press upon us the *inherent probability* of the existence of a resisting medium in the celestial spaces. The connection between our organs of sense and *remote bodies* necessarily implies the existence of some *intervening medium ;* and, moreover, to convey a *physical* impression to the organ of sense, this medium must be *material.* Whatever theory of light we adopt, we are equally driven to the conception of the existence of some form of *matter* in the celestial spaces. The fact that light and heat are propagated from one part of space to another in *time* demands that the medium of communication should possess *inertia*—an *essential* property of *matter*. According to the *wave theory*, the celestial bodies move in an attenuated and subtile *ethereal medium;* according to the *corpuscular theory*, they move in a perpetual *shower of corpuscles* emitted by the sun and stars. In both cases *matter* exists—*inertia* exists—therefore *resistance* must be encountered. The *smallness* of the resistance, however small we choose to suppose it, does not allow us to escape this certainty. There is resistance, and therefore the movements of satellites *cannot escape its influence.* Nevertheless, such *attenuated* and *bulky* masses as *comets* are best adapted to *test* the existence of a *resisting medium.*

3. In the last place, it is possible that Mars may have *originally* rotated on his axis *in five or six hours*, but that the *tidal rotation-retardation* produced by the action of his moons might have brought about its *present* rotation-period. It is evident that the solar tides, on a planet so small and so remote from the sun, must be inappreciable; and, at first sight, the lunar tides produced by such small masses might be supposed to be equally insignificant. But it must be recollected that the tide-generating power of a moon is (other things being equal) *inversely* proportional to the *cube* of its distance; so that *nearness* might more than compensate for *smallness* of mass. To be more specific: In the mathematical language, the tide-generating power is in proportion to the

$$\frac{\text{Diameter of Primary} \times \text{Mass of Satellite}}{(\text{Distance of Satellite.})^3}$$

Thus, for example, let us suppose the diameter of our moon to be twenty times the diameter of the inner satellite of Mars, and both moons to be equally *dense;* then the *mass* of our moon would be 8,000 times that of the Martial satellite. Taking the diameter of the earth as equal to twice the diameter of Mars (and it is not so great), and the distance of our moon from the center of the earth to be forty-one and a half times the distance of the inner satellite from the center of Mars, we then have the tide-generating power of our moon acting on the earth, will be to that of the inner satellite acting on Mars as $\frac{2 \times 8000}{(41\frac{1}{2})^3}$ to 1, or as $\frac{16000}{71473}$ to 1, or as $\frac{1}{4\frac{1}{2}}$ to 1, or as 1 to $4\frac{1}{2}$. Hence, the tide-generating power of this small satellite would, in consequence of its *nearness* to Mars, be about four and a half times as great as the tide-generating power of our moon on the earth.

This view, however, is not free from the most *serious physical difficulties.* For it is evident that the tidal rotation-retardation produced by the moons would be *limited* by the final condition, that the *rotation-period* of the primary becomes exactly the *same* as the *orbital-period* of the satellite. When this condition is attained, the tides can no longer retard the rotation-period of the planet. So far, therefore, as the *inner* moon of Mars is concerned, it must long ago have *ceased* to retard the rotation of the primary. For, the orbital-period of this satellite being far *shorter* than the present rotation-period of Mars, its tidal action would tend to *accelerate* instead of *retarding* the time of rotation of the planet. So far as the *outer* moon is concerned, it is evident that its tidal action must tend to *retard* the rotation-period of Mars; but, in consequence of its greater *remoteness*, the magnitude of its influence must be *small* compared with that of the *inner* satellite. It is, therefore, difficult to conceive how the tidal influences of the moons of this planet can explain the anomalous fact that its rotation-period is *longer* than the orbital-period of one of its satellites.

In connection with the idea of the rotation-period of Mars having, at some *former time*, been much *shorter* than it is at present, it may be noticed that the great compression or ellipticity of this planet is totally inconsistent with its observed rotation-period.*

In 1784 Sir William Herschel estimated the ellipticity of Mars at $\frac{1}{16}$. Schröter refused to admit this result; he contended that, if the ellipticity existed, it would not exceed $\frac{1}{80}$. Bessel failed to discover any appreciable ellipticity of Mars, even with the celebrated heliometer of Königsberg. On the other hand, Arago's measurements, executed at the Observatory of Paris, from 1811 down to 1847, all confirm the existence of an ellipticity in this planet of about $\frac{1}{30}$. ("Astronomie Populaire," tome iv., p. 130. Paris, 1867.) More recent observations give somewhat contradictory results. Professor Kaiser, of Leyden, makes the ellipticity $\frac{1}{114}$; Main, of the Radcliffe Observatory, deduced $\frac{1}{39}$ in 1862; and Dawes's measurements give negative results.

To show the discordance of these results with what may be deduced from the theory of gravitation, it must be recollected that the *ellipticity* of a rotating planet depends upon the *ratio* of the *centrifugal force* at its equator to the *force of gravity* at the same place. Thus, to compare the earth and Mars—

Let r and r' = equatorial radii of earth and Mars respectively.
" t " t' = time of rotation " " " " "
" Q " Q' = mass " " " " "
" f " f' = centrifugal force at equator " "
" g " g' = force of gravity " " " " "

* The *oblateness* or *compression* or *ellipticity* of an oblate spheroid is the *difference* of its equatorial and polar radii, divided by its equatorial radius. Thus, if a and b are the equatorial and polar radii respectively, then ellipticity $= \frac{a-b}{a}$.

Then, by dynamical principles, we have—

$$f : f' :: \frac{r}{t^2} : \frac{r'}{t'^2},$$

and

$$g : g' :: \frac{Q}{r^2} : \frac{Q'}{r'^2}.$$

Now, for these two planets we have—

$r = 3962{\cdot}8$ miles, and $r' = 2100$ miles.

$t = 86164$ seconds, " $t' = 88643$ seconds.

$Q = \frac{1}{326690}$, and $Q' = \frac{1}{3090000}$ of mass of the sun.

Substituting these numbers in foregoing proportions, and performing the arithmetical operations, and we have—

$$f : f' :: 1 : 0{\cdot}500704, \text{ and}$$
$$g : g' :: 1 : 0{\cdot}376482.$$

Hence we have $\frac{f}{g^1} : \frac{f'}{g'} :: 1 : \frac{0{\cdot}500704}{0{\cdot}376482}$ or $1 : 1{\cdot}32996$. But, for the earth, $\frac{f}{g} = \frac{1}{289}$; hence we have $\frac{1}{289} : \frac{f'}{g'} :: 1 : 1{\cdot}32996$. Consequently for Mars we have $\frac{f'}{g'} = \frac{1{\cdot}32996}{289} = \frac{1}{217}$. Now, according to the elegant theorem of Newton, if the rotating planets were *homogeneous liquid masses*, their *ellipticities* would be $\frac{5}{4}$ of $\frac{1}{289} = \frac{1}{231}$ for the earth, and $\frac{5}{4}$ of $\frac{1}{217} = \frac{1}{174}$ for Mars. These are the *greatest possible* values of the *ellipticities* for these two planets with their *present* rotation-periods.* In the case of the earth, we know that it is much *smaller;* being about $\frac{1}{300}$ instead of $\frac{1}{231}$. Hence, for Mars also, we should expect an ellipticity *smaller* than $\frac{1}{174}$; whereas, as we have seen, nearly all the measurements indicate a much *greater* ellipticity.

It is evident that a more *rapid rotation* of the planet would *augment* its ellipticity; hence the question naturally suggests itself: Might not this great ellipticity of Mars have been the result of solidification having taken place when his rotation-period was much *shorter* than it is at present? This explanation is not free from serious difficulties. For, if aqueous and aërial agencies were in action after solidification took place, they would have tended to make the shape of the planet conform to its new rotation-period.

* That the values of ellipticity deduced from the assumption of an *homogeneous liquid mass* in the rotating planet must be *maxima* is evident from the consideration that, if the *density augmented* from the surface toward the center of the planet (which must, from the compressibility of matter, be the *real* condition of things), it would render the computed ellipticity *smaller.* The problem of the *theoretical figure* of a rotating planet is greatly *complicated* as soon as we abandon the assumption of *homogeneousness.*

INTELLECTUAL STRAINING IN AUTHORSHIP.

WE hear a good deal of the joylessness of the present generation, and no doubt there is a greater unrest and a greater impatience among those who lead the forward movement of thought than in any former time. And partly, no doubt, this is due to want of trust, want of power to lean on any invisible hand ; partly, too, to a habit closely connected with this want of trust—a habit contracted by men of the greatest intellect, of straining to see or say something new, as if such straining were the only healthy condition of the mind, as if without it one must sink into a sort of death. Carlyle was one of the first to set the example of this straining. His genius, great as it is, may be almost said to have grown out of the taste for abrupt changes of light and shadow, in the flickerings of which he has contrived to set so considerable a tract of life, both domestic and historic. His peculiar dialect itself is a great instrument for startling men, for giving them little shocks or thrills of unexpected impression. Very often, too, he has succeeded, as some great photographers have succeeded, in producing a very powerful impression by deliberately taking his portraits out of focus. Carlyle's influence is in this respect more or less reflected in Ruskin, who has taught the younger generation of Oxford men so much and yet often so grotesquely, who has fostered so much more excitement of mind than is healthy, and who has accustomed them to so much disproportion between the vehemence of what he says and its truth. And, of those of our younger generation who go abroad for tuition, how many prefer Victor Hugo to any home-bred master for this very reason alone—that his genius is so irregular and grotesque, that it combines so much excitement with so much insight, that there is such a piercing glance and so little law ! It is the same in the New World. There are many who believe that Ralph Waldo Emerson is the greatest of living sages. And certainly his career has been calm and sedate enough, and there is real penetration in his glance. But, though he has never thrown much of emotional excitement into his teaching, his philosophy means nothing, if it does not mean that you get a truer view of life by standing on intellectual tiptoe and straining at a universal truth that is not quite within your reach than you do by humbly putting together what you may really be said to understand. There is no greater contrast between intellectual men than there is between the sedate calm of Emerson and the transcendental exultation or anguish of Victor Hugo. But, on a purely intellectual theme, the one reminds us curiously of the other. Here is a preface furnished by Emerson to a series of portraits of the hundred greatest men of the human race, which has just been begun by an enterprising publisher.*

* Messrs. Sampson Low & Co.

How does he try to interest the reader in the images of these hundred greatest figures of history? Why, by writing thus: "The great are our better selves, ourselves with advantages. It is the only platform on which all men can meet. If you deal with a vulgar mind, life is reduced to beggary. He makes me rich, him I call Plutus, who shows me that every man is mine, and every faculty is mine—who does not impoverish me in praising Plato, but contrariwise, is adding assets to my industry." Well, that alone seems to us pure strain to say something new, without much care whether or not it be true. Beethoven's faculty is not mine, whether I like to say so or not—nay, nothing can make it mine; probably nothing can make me even understand it. Great men are not our better selves, they are only something that our better selves very slowly learn to apprehend. But as if that were not overstrained enough, Emerson goes on: "An ethereal sea ebbs and flows, surges and rushes hither and thither, carrying its whole virtue into every creek and inlet which it bathes. To this sea, every human house has a water-front. Every truth is a power. Every idea, from the moment of its emergence, begins to gather material force, after a little while makes itself known. It works first on thoughts, then on things; makes feet, and afterward shoes; first hands, then gloves; makes men, and so the age and its material soon after. The history of the world is nothing but a procession of clothed ideas. As certainly as water falls in rain on the tops of mountains, and runs down into valleys, plains, and pits, so does thought fall first in the best minds, and runs down from class to class until it touches the masses, and so makes revolutions."

We have heard that kind of thing from Mr. Emerson now for so many years, that it has almost the charm of an old, old landscape, to find him saying again now what he said in the first volume which Mr. Carlyle introduced to the British public with the unique emphasis of one of his peculiar redundancies of repetition, "The words of such a man, what words he thinks fit to speak, are worth attending to." But no one, we think, who puzzled out Mr. Emerson in his youth, and has since compared his mode of presenting the Pantheistic idea with that of other thinkers, will regard it as a simple or natural mode—quite apart from any opinion as to the truth or falsehood of the idea itself. It is emphatically an unnatural and paradoxical mode of presenting it. It is the mode of a man who wishes to say something grander than any clear thought he can express, something that does not fit the thought so much as attract attention to it by phraseological unsuitability and extravagance. It is the style of one of the *Illuminati*, not of simple, sincere philosophy.

And even among a very different school—the school of what we may call physical skepticism, as distinguished from transcendental skepticism—there is the same tendency to intellectual strain, as in the case of the late Professor Clifford—a man of whom his biographer tells us that, before taking his degree at Cambridge, and for some little time afterward, he was "an ardent High Churchman," but who within ten years of that time gravely assured his Sunday audience as follows:

"On the whole, therefore, we seem entitled to conclude that, during such time as we can have evidence of, no intelligence or volition has been concerned in events happening within the range of the solar system, except that of animals living on the planets. The weight of such probabilities is, of course, estimated differently by different people, and these questions are only just beginning to receive the right sort of attention. But it does seem to me that we may expect in time to have negative evidence on this point of the same kind, and the same cogency, as that which forbids us to assume the existence between the earth and Venus of a planet as large as either of them."

It is hardly possible to regard a statement of that kind, made by a brilliant young man to a popular audience, within a few years of the time when he was himself an ardent Christian, and on the mere strength of the assumption that "mind without brain is a contradiction," except as the result of a delight in intellectual straining for its own sake. It is not merely that the atheistic drift is intrinsically so audacious and violent, but that the mode of its statement is still more audacious and violent. To assert that a disproof of a divine intelligence might be expected of the same degree of validity as the disproof of the existence of a large inferior planet, in a position in which its influence would long ago have been detected, both directly and indirectly—where, indeed, it would have vitiated every calculation made for a century and a half at least—can hardly have been the result of anything but a sheer desire to inflict a great intellectual shock, to produce the excitement of a new intellectual strain. It was, indeed, the product of the same state of mind which made the same brilliant paradox-monger enjoy saying, when at college, "There is one thing in the world more wicked than the desire to command, and that is the will to obey." But that startling saying was commonplace itself compared with those statements which he made as a mature man many years later, to a large and indiscriminate popular audience. And, in his great philippic against the sin of credulity, he strains matters often to a point as shrill. Nay, even Mr. Pollock, in writing his memoir of his friend, appears anxious to strike a similar chord. Speaking of Clifford's last days, he says: "Far be it from me, as it was far from him, to grudge to any man or woman the hope or comfort that may be found in sincere expectation of a better life to come. But let this be set down and remembered, plainly and openly, for the instruction and rebuke of those who fancy that these dogmas have a monopoly of happiness, and will not face the fact that there are true men, ay, and women, to whom the dignity of manhood and the fellowship of this life, undazzled by the magic of any revelation, unholpen of any promises

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It is hardly possible to regard a statement of that kind, made by a brilliant young man to a popular audience, within a few years of the time when he was himself an ardent Christian, and on the mere strength of the assumption that "mind without brain is a contradiction," except as the result of a delight in intellectual straining for its own sake. It is not merely that the atheistic drift is intrinsically so audacious and violent, but that the mode of its statement is still more audacious and violent. To assert that a disproof of a divine intelligence might be expected of the same degree of validity as the disproof of the existence of a large inferior planet, in a position in which its influence would long ago have been detected, both directly and indirectly—where, indeed, it would have vitiated every calculation made for a century and a half at least—can hardly have been the result of anything but a sheer desire to inflict a great intellectual shock, to produce the excitement of a new intellectual strain. It was, indeed, the product of the same state of mind which made the same brilliant paradox-monger enjoy saying, when at college, "There is one thing in the world more wicked than the desire to command, and that is the will to obey." But that startling saying was commonplace itself compared with those statements which he made as a mature man many years later, to a large and indiscriminate popular audience. And, in his great philippic against the sin of credulity, he strains matters often to a point as shrill. Nay, even Mr. Pollock, in writing his memoir of his friend, appears anxious to strike a similar chord. Speaking of Clifford's last days, he says : "Far be it from me, as it was far from him, to grudge to any man or woman the hope or comfort that may be found in sincere expectation of a better life to come. But let this be set down and remembered, plainly and openly, for the instruction and rebuke of those who fancy that these dogmas have a monopoly of happiness, and will not face the fact that there are true men, ay, and women, to whom the dignity of manhood and the fellowship of this life, undazzled by the magic of any revelation, unholpen of any promises holding out aught as higher or more enduring than the fountain of human love and the fulfillment of human duties, are sufficient to bear the weight of both life and death. Here was a man who utterly dismissed from his thoughts, as being unprofitable, or worse, all speculations on a future or unseen world; a man to whom life was holy and precious, a thing not to be despised, but to be used with joyfulness; a soul full of life and light, ever longing for activity, ever counting what was achieved as not worthy to be reckoned in comparison of what was left to do. And this is the witness of his ending, that as never man loved life more, so never man feared death less. He fulfilled well and truly that great saying of Spinoza, often in his mind and on his lips, '*Homo liber de nulla re minus quam de morte cogitat*.'"

There is surely a clear straining after startling announcements in the very manner of this passage. Why does Mr. Pollock fall into the manner of our translators of Scripture, with his "unholpen of," and the unmeaning adjective which, from his point of view, he chooses for Professor Clifford's view of life, namely, "holy," unless he wants to emphasize, by the use of such affectations, the antithesis between his meaning and the meaning of the book of which his turns of phrase remind us? And, however true it may be, as it doubtless was, that Professor Clifford met death with the courage and calmness that befit a man in meeting the inevitable, it is clearly nothing but an exaggeration, and an attempt to strain beyond the truth, to endeavor to make us believe that, if, as we are told, Professor Clifford was a man of warm affections, he did not fear death any the more, believing it, as he did, to be the extinction of love, than he would have done if he had thought it but the entrance on a life of deeper and truer love. What Spinoza says is well said for a man of action and for a man of thought, but very ill said, indeed, for a man of loving nature. Thought and action are so full of the present that they do not live in the future. True affection can not but shiver at the thought of extinction, and with Professor Clifford, too, doubtless it was so, as it would be with any one else. It does not follow that, because a man is brave and reticent, he does not suffer from the pang he conceals. If it could be shown that in relation to his personal affections he really feared death less than those who do not regard it as the end of either life or love, all we can say is that the only proper inference would be that he feared it less, because to him it signified less, because he loved less. And that is not at all the inference we should draw from the facts of his life. We suspect that Mr. Pollock is only imitating his friend in straining after a startling saying, without considering that what is intellectually startling is not, on that account, the more, but the less likely to be true.

This tendency to strain after intellectual excitements and surprises, which has flowed from so many quarters upon the present generation, is a very natural accompaniment of an age of discovery and of popular education—an age when people have been taught to expect constantly new advances, and, in a rough kind of way, even to approciate the enjoyment of an intellectual change of air. But though this love of change may be appropriate to a state of progress, we must remember, after all, that it is most inappropriate to a state of knowledge. The condition of the highest knowledge is the condition of least surprise. The more we have that is real to lean upon the less excuse there will be for this straining and craning of the neck after startling intellectual novelties. Even now we are sure that the tendency to grasp at new ideas is often fatal, not merely to the utilization of old truths, but to the mere holding of the ground which had been gained by our ancestors. All this razing to the earth of the moral and religious beliefs of former days is far more loss to man than the best of the new glimpses of truth are gain. And, indeed, the tendency is to eradicate the temper of repose, the heart of confidence in what has been gained, and to substitute for it a constant reliance on the stimulus of an intellectual excitement the very essence of which depends on change. Professor Clifford begins one of his lectures by pointing out that if any one will consider what he has done during that day, that which he has done oftenest is to change his mind—i. e., not to alter his resolves, but to change the subject-matter of thought and resolve. It is very true, but the tendency of Professor Clifford's and his clique's teaching is to something much more dangerous—to make change of mind an object of aspiration, and almost of moral duty; to depreciate the value of the leaning disposition which rests on what is old, and to overrate that of the mercurial disposition which cares only for what is novel.—*Spectator*.

RESPECTING RUBBISH.

MOST of the substance we call the rubbish of our houses finds its way sooner or later into the dust-bin, and thence into the dustman's cart, which conveys it to the dust-contractor's yard; and there we are for the most part contented to lose sight of it. It is worthless to us, and we are thankful to be rid of it, and think no more of it. But no sooner does it reach its destination in the yard than our rubbish becomes a valuable commodity. The largest cinders are bought by laundresses and braziers, the smaller by brickmakers. The broken crockery is matched and mended by the poor women who sort the heaps, that which is quite past repair being sold with the oyster-shells to make roads; and the very cats are skinned, before their dead bodies are sent away with other animal and vegetable refuse to be used as manure for fertilizing our fields. Nothing is useless or worthless in the contractor's eyes; for rubbish, like dirt, is simply "matter out of place."

The term is an entirely correlative one ; what is rubbish to one person under certain circumstances being under altered conditions extremely valuable to another. Gold itself is rubbish in the eyes of a man who is starving on a desert island ; and the pearls which adorn a royal diadem, and have made the fortune of the lucky finder, were probably felt to be worse than useless by the poor oyster, tormented by the presence of some particle of matter which he felt to be decidedly "out of place" within his shell. Many a cook, no doubt, has washed the little fresh-water bleak, a fish about four inches long, and had thoughtlessly poured away the water after the operation, before it occurred to the French bead-maker that the lustrous silvery sediment deposited at the bottom of the vessel might be turned to account in the manufacture of artificial pearls, or pearl-beads.

It is, indeed, strange to consider how many of our most highly prized adornments and our most useful and important manufactures are derived from our own and Nature's refuse. The jet which brings in some twenty thousand pounds a year to the town of Whitby alone is merely a compact, highly lustrous, and deep-black variety of lignite a species of coal less ancient in origin than that of the Carboniferous era which we usually burn. And coal itself, as we know, is merely the refuse of ancient forests and jungles, peat-mosses and cypress-swamps, which has been mineralized in the course of ages and stored for our use in the bowels of the earth. Amber, too, which is also used for ornaments, especially in the East, is but the fossil gum or resin of the *Pinites succinifer*, large forests of which seem to have existed in the northeast portion of what is now the bed of the Baltic. To the pine-tree this gum was certainly nothing but refuse, a something to be got rid of ; but Nature, who rejects nothing however vile and contemptible, received it into her lumber-room, her universal storehouse, and, after keeping it patiently much more than the traditional seven years, sends it out again, transformed and yet the same, to adorn the Eastern beauty, and to give employment to many a skillful pair of hands. Bogwood, which, like jet, is used for bracelets, brooches, etc., is merely oak or other hard wood which has lain for years in peat-bogs or marshes, and has acquired its dark coloring from the action of oxidized metal upon the tannin it contained.

Turning, however, from Nature's processes to those of man, we find that he is doing his best, however clumsily, to follow the thrifty example she sets him. For many and many a year no doubt the pine-tree shed its pointed, needle-like leaves in the Silesian forests, and there they were left to decay and turn into mold at their leisure, until M. Pannewitz started a manufactory for converting them into forest-wool, which, besides being efficacious in cases of rheumatism when applied in its woolly state, can also be curled, felted, or woven. Mixed with cotton, it has even been used for blankets and wearing apparel. The ethereal oil evolved during the preparation of the wool is a useful medical agent, besides being serviceable as lamp-oil and also as a solvent of caoutchouc ; and even the refuse, left when the leaves have yielded up their oil and wood, is not looked upon as rubbish, but is compressed into blocks and used for firewood, while the resinous matter it contains produces gas enough for the illumination of the factory.

Truly, as one man's meat is another man's poison, so one man's rubbish is another man's treasure. While the Russians export or simply waste all their bones, other more thrifty people boil them, to extract their grease and gelatine ; convert them into charcoal, to be used in refining sugar ; pass them on to the turner, to be made into knife-handles and a thousand other useful articles ; or grind them up to supply phosphate of lime for the farmer's crops. The commonest and roughest kinds of old glass are now bought up by a certain manufacturer, who melts them up, colors the liquid, by a secret process of his own invention, to any tint he desires, and finally pours it out to cool in flat cakes. These are broken by the hammer into fragments of various size and shape, which are used to produce most effective decorations, such as might be introduced with advantage in many a now plain unattractive-looking building. The cost of this variety of mosaic is less than that of any other, and no doubt it will be extensively used as it becomes better known.

Even such insignificant things as cobwebs are turned to account, not merely for healing cut fingers—Bottom's sole idea as to their use—but for supplying the astronomer with cross-lines for his telescopes. Spiders' threads have even been woven, though one can not imagine where or how, except in fairy-land, by fairy fingers, and for fairy garments ; and among the curiosities which travelers bring home from the Tyrol are pictures painted upon cobwebs, the drawing of which is perfectly clear and distinct, with the spider's handiwork at the same time plainly apparent. High prices are charged for these strange works of art, and no wonder, for the cobweb paper—which resembles a fluffy semi-transparent gauze—looks as if it must be extremely unpleasant to draw upon ; and no doubt the eccentric artist fails many times before he succeeds in producing a salable article. But we may descend even lower than cobwebs in the scale of refuse, and still find that we have not reached the dead-level at which things become utterly worthless and good for nothing. Nay, much that is sweetest and associated in our minds with luxury and refinement may now be produced from that which is in itself most repulsive ; for, while artificial vanilla can be made from the sap of the pine-tree, essence of almonds from benzine, and the delicate perfumes of woodruff and melilot from coal-tar, other scents as fragrant can be obtained from the unsavory refuse of the stable.

Perhaps there is nothing more interesting and instructive, as showing how the meaning of the word "rubbish" varies, than the history

Such is the essayist's introduction; and that he deems his ambitious project to have been triumphantly accomplished is evident from the words of his conclusion: "But it is unnecessary to pursue this point any further. We have already said enough to satisfy our present object, which is simply to expose the weakness of the reasoning (if reasoning it could be called) by which the theory before us is assumed to be maintained. The question is essentially one to be decided by the exercise of the judicial faculties, . . . and if so dealt with, apart from all fanciful speculation, we feel no hesitation in asserting that the conclusion will be that at which we ourselves have long since arrived, viz., that development by evolution is merely a rhetorical expression, a form of words, and nothing more."

It will thus be seen that the reviewer's purpose is sufficiently sweeping; and, considering he is not blind to the fact that the weight of competent authority is against him (p. 225), we must at least be startled by the boldness of the man who, without any armor of fact either on the right hand or on the left, rushes like David full of self-confidence against the Goliath of modern thought. The stone which is hurled is indeed in one respect a stone of tremendous weight, the style of the article being ponderous to a degree that borders on pomposity. But, unfortunately, if there is a hole in the armor of the giant, the stone has certainly failed to hit it; and, as the modern champion of Israel has evidently found the armor of fact too heavy to put on, he must not now object to receiving some rough treatment at the hands of the foe which he had the courage to attack.

The allusion to the writer's evident ignorance of science leads me to say at the outset that it is not my intention to waste time by troubling him upon this subject. He expressly says in the passage already quoted that he does not intend to contemplate matters of scientific fact, but to discuss the whole question of evolution "on broader philosophical grounds." It is impossible not to recognize the wisdom of this resolve. When a man supposes that elemental matter is now affirmed to be only one substantial form, at present subsisting in the condition of a gas (the hydrogen—p. 221), or that it is the rule "in the case of ophidian reptiles, serpents, etc.," that "the places assignable to the arms and legs in other animals are occupied by rudimental representatives of those organs imbedded in the surrounding tissues" (p. 228); that paleontology reveals only "a solitary case of approximation to the equine species"; that the sum total of animal species amounts to only one hundred and twenty thousand; and so on—a man, I say, who supposes such things, is no doubt wise to abstain from "critically reviewing" scientific facts. I shall proceed to show that he would have been still wiser had he also abstained from trespassing "on the broader philosophical grounds" of scientific theory.

Taking the features of his article *seriatim*, we may first observe that in his opening paragraphs he displays an altogether erroneous estimate of what is meant by the faculty of scientific observation. He makes a broad distinction between the "faculties of *observation* and of *ratiocination* or *reasoning*," and states that "they are, in fact, the distinctive characteristics of two different classes of men, regarded with reference to their intellectual endowments. The man of observation, prone to notice and apt to discern the peculiarities of form and substance—all, in short, that comes within the cognizance of the senses—is by no means equally apt to discern, or competent to appreciate, the conclusions to which they are calculated to conduce; while, on the other hand, the man of reasoning, accustomed to deal with the suggestions of the mind rather than of the senses, prone to speculation rather than to experiment, is comparatively unfitted for the more matter-of-fact employment of investigation and research. Both classes of minds and of men are equally essential to the progress of scientific discovery, though it can not be said that both stand on the same level in the estimation of their respective faculties. The faculty of observation, important as it is, is a faculty common, not merely to all men, but more or less to all animated beings, whereas the faculty of reasoning, at least in its higher grades, is peculiar to man alone."

Now, that there is a distinction to be drawn between an observant and a contemplative mind—between a man who sees and a man who thinks—there can be no question. But, that the distinction is of the kind here drawn, no one in the least degree acquainted with experimental research could for a moment suppose. The idea of the writer seems to be that all scientific observation consists merely in a refined use of the senses, the things to be observed lying in Nature already formed, like shells upon the beach. Such an idea is applicable only to the pursuits of a species-hunter, or "systematist"—a man who holds merely the rank of a private in the scientific army. For the discovery of all that deserves the name of scientific truth, for the classifying of hidden analogies and the unveiling of general principles, the highest faculties of the human mind, in the highest degree of their development, must be taxed to the highest degree of their power. With a clear perception of the problem to be solved, a man of science must either think out the particular conjunction of conditions occurring in Nature, which, if found to occur, would give an unequivocal solution, or he must devise such an artificial conjunction of conditions as may lead to the same result. And whether, as in astronomy and geology, the former method be employed, or the latter method be employed, as in all the experimental sciences it must be, I fearlessly affirm that in no department of intellectual activity is there a greater demand made upon that particular faculty of mind which our author terms the faculty of ratiocination. If we follow the intellectual operations by which any of the greater results in science have been achieved, their most conspicuous feature will always be found to consist in the number, the length, and the intricacy of the chains of reasoning converging now upon this point and now upon that, as each is made the securely-fastened point of attachment for the next. The great distinction between the reasonings, say of the metaphysician and the man of science, consists, not in any difference of degree, but in a difference of subject-matter. For, while the man whom our author calls the "man of reasoning" has no other test by which to estimate the accuracy of his conclusions than the subjective processes of reason itself, "the man of observation" has the uncompromising court of objective fact whither to bring his conclusions for a trial that is sure to be remorseless, and for a judgment from which there can be no appeal. And because the court of Nature is alone infallible, the man of science shows his wisdom as a seeker of truth by directing his best faculties of thought toward the arguing of his case in such a way that the judgment of this court upon the issue presented shall be final. The issue is that concerning the truth of a laboriously reasoned hypothesis; the argument is a perhaps no less laboriously reasoned experiment; and the judgment is either a triumphant verification or a crushing non-suit with costs—the latter being now happily to some extent defrayed by government. In a word, to disparage those faculties of mind which elaborate scientific generalization, as contrasted with those which elaborate philosophic speculation, is surely too preposterously absurd to be entertained even by the most benighted reader of the "Edinburgh" or any other Review.

The author of this attempt appears, from the authoritative style in which he writes, to regard himself as among the favored "men of reasoning, prone to speculation rather than to experiment." That he would be "comparatively unfitted for the more matter-of-fact employment of investigation and research," we can not entertain the shadow of a doubt, and therefore I see no reason why we should hesitate to place him in the category of those who are "accustomed to deal with the suggestions of the mind," without condescending to bring these suggestions to the test of fact. If so, I grieve to observe that in this case the suggestions of the mind have certainly been of a most unfortunate character.

He first briefly considers the present balance of authority regarding the question of spontaneous generation, or the development of living from non-living matter. On this subject I have no remark to make, except that, so far as the doctrine of evolution is concerned, there is no *a priori* reason to anticipate the occurrence of spontaneous generation within the limits of time that are possible to human observation. Miserably small as is our knowledge of protoplasm, we at least know enough to be astounded at its enormously complex chemical constitution, and the no less enormously complex physical properties with which it is endowed. The numerous species of elaborately sculptured shells which owe their varied and intricate forms to the vital activities of protoplasm; the fact that all cells, and therefore all organizations, ultimately owe their forms and their functions to the apparently same material; and, lastly, the fact that all specific organisms spring from minute specks of this substance, which specks therefore contain and transmit the vital record of billions on billions of hereditary qualities, specific and individual—these things show that the term protoplasm must be considered as merely a general term for all living matter, the constitution of which may perhaps in some cases be comparatively simple, while in others it must be immensely complex, the only common feature of protoplasmic material being that its constitution is too minute for the microscope to analyze. But even if we suppose that the constitution of the simplest form of existing protoplasm—whatever that may be—is as simple as we choose to suppose, it must at least be enormously complex as compared with any known form of non-living matter. Therefore an evolutionist, or a man who believes in the doctrine of gradual development in nature, is certainly not the man who would be prepared *a priori* to expect the spontaneous production of protoplasm within any period that it is competent for experiment to span. If experiment should ever succeed in unequivocally producing protoplasm by artificial means, the fact would, of course, be an immense gain to science, and by bridging the chasm between the physical and the vital would be also a gain to the doctrine of development. But the absence of any such experimental proof of continuity is no presumption against that doctrine, so long as the presumption remains that if the passage from the non-living to the living ever took place it must have taken place by slow degrees.

Passing over the reviewer's comments on the theories of Lamarck and the author of the "Vestiges," I shall at once proceed to examine the main portion of his review, which is simply an attempt at a criticism of Mr. Darwin's work. Here he says: "With the facts, our only concern is to understand them, that we may be able to reason from them. Our business is with the conclusions, to test their correctness in accordance with the recognized principles of right reasoning, that error may be eliminated and truth secured." We shall see that it can not well be said whether it is in understanding the facts, or in testing the conclusions, that this writer has shown himself the more deplorably incompetent.

First, he undertakes to expound and to criticise what he properly terms the distinctive "peculiarity" of Darwinism—the doctrine of natural selection. It may well be thought incredible that at the present day an educated man, writing in a respectable review on the subject of Darwinism, and introducing his criticism with all the solemn flourishes of pedantry that I have quoted, should at once proceed to show that he is entirely ignorant of what the doctrine of natural selection is. Yet such is the fact, and the heavy charge of uninstructed arrogance which I thus level at the writer in question is but too easily maintained by the following quotations (pp. 225–227):

This instrumentality was at first supplied in the theory of Dr. Darwin by the "struggle for life," occasioning the disappearance from the scene of the feeblest and the "survival of the fittest" to carry on the race. The notion is a striking one; and with the advocacy of its able author, his charming style, and the interesting illustrations by which it was supported, naturally produced a powerful impression upon the public mind. A little consideration, however, gradually weakened the first effect. It was presently observed that such a description was only properly applicable to a certain class of animals—the *polygamous*, in which one male in the herd or flock assumes possession of all the females; and to that class but imperfectly, making no account of the females, whose influence in determining the condition of the offspring is at least equal to that of the males. . . .

With regard to the two propositions upon which the Darwinian theory essentially depends, we have already alluded to an apparent objection to the first mentioned, the "struggle for life," and which is indeed equally predicable of the other, the principle of "selection in relation to sex"—namely, that it is limited in its application to certain classes of animals, and those neither the most numerous nor the most important. For we confess we can not understand how either of them could be supposed to prevail at all in at least one whole department of animal life—the *aquatic*. Surely there is but scant room for the hypothesis of a "struggle for life," and still less for that of "selection in relation to sex" among fishes! And these, with the other denizens of the deep, constitute more than one half of the animal kingdom. But there is yet another point of view in regard of which both the conditions in question are obviously inadequate to the conclusion that is built upon them—namely, that it is only in the already advanced stages of animal subsistence that they come into operation at all. The "struggle for life" and "selection in relation to sex" could have no scope for exercise among the lower forms of life; many of them without the power of locomotion, incapable of either seeking their food or choosing their mates. And yet these are, in the theory before us, the foundation of the animal superstructure, comprising the earlier stages of that progressive development which by those means is supposed to be accomplished.

From these passages we can only suppose that their writer believes what he states, viz., that Mr. Darwin's theory of natural selection in the struggle for life is limited to natural selection in what Mr. Darwin has called "the law of battle." In all animals that fight among themselves Mr. Darwin supposes that strength, courage, and all other qualities conducive to success in battle, are some of the qualities which in such animals constitute that "fitness" to survive which is laid hold upon by natural selection in the struggle for existence, and perpetuated in advancing degrees by heredity. But to suppose that the struggle for existence is limited to a literal fighting among animals is a misconception so extraordinary that it could scarcely be suspected, were it not so carefully enforced by the writer himself. Why else should he mention only "the *feeblest*" as those individuals which must disappear in the struggle for life? or why else should the process of natural selection be restricted in its operation to such animals as are "polygamous"? And how else can there be any meaning in the statement that "we confess we can not understand how either of them could be supposed to prevail at all in at least one whole department of animal life—the *aquatic*," or "that the struggle for life could have no scope for exercise among the lower forms of life," etc., etc.? The truth can only be that this writer has either never read Darwin at all, or that he has forgotten the most distinctive principles of which Darwinism consists. For, it would be needless to tell nine persons out of ten who may read this reply, that Darwin is most explicit in assigning a very subordinate place to the function of actual contest in the struggle for existence; he supposes a host of other agencies to be of far more importance in determining the fitness of the survivors—a host, indeed, which it is literally true that no man can number. Doubtless the poetic force of Mr. Darwin's metaphor has ludicrously misled his critic; and, if the latter were to substitute for it some such term as Competition for Life, it is impossible that we could hear anything more even from the "feeblest" unfortunate among the strugglers against evolution, about being unable to understand how the principle could apply to the lower forms of life.

The remarks, then, which I have quoted concerning natural selection clearly prove that that writer has either never read, or has entirely forgotten, the "Origin of Species." His remarks simultaneously quoted concerning sexual selection further prove that he has either never read, or has entirely forgotten, the "Descent of Man." Otherwise it would have been impossible for him to write, with all the added emphasis supplied by a mark of admiration, "Surely there is but scant room for the hypothesis of a 'struggle for life,' and still less for that of 'selection in relation to sex,' among fishes!" A reviewer has a perfect right to differ to any extent he pleases with the writer whom he reviews, provided that he gives some evidence of having read the works of that writer; but a man who, "listening to the suggestions of his own mind," thinks that he is making a strong point by propounding, as a *reductio ad absurdum*, a belief which the author he reviews has brought a large quantity of evidence to support—such a man can only be deemed a foolish adventurer in the province of criticism. Whether or not sexual selection obtains among fish may properly be regarded as an open question, and the supposition that it does may, perhaps, seem to some persons unlikely, even after they have read all that Darwin has to say upon the subject. But any dubiousness of the doctrine itself does not affect the evidence, which is supplied by the *reductio ad absurdum* form, that the reviewer is ignorant that Darwin has seriously advocated the possibility of sexual selection occurring among certain aquatic animals.

Having spoken of the reviewer's ignorance of the "Origin of Species" and the "Descent of Man," I may next allude to his ignorance of the "Variation of Plants and Animals under Domestication." Here, at least, total ignorance of the work he names is the most charitable construction that we can put upon the following passage:

We can not admit that anything deducible from such premises can have any application in the case before us. What we are here concerned to determine is the effect of the operation of the laws of nature in the state of nature; and this can not be affected by anything that could be achieved in a state in which those laws are superseded by *un*-natural restraints. The conditions of existence in a state of domestication, whereinsoever they differ from those in the state of nature, are by their very definition peculiar to the state of which they are predicated, and consequently out of place in an argument that concerns the ages which preceded the advent and dominion of man. Granted the very utmost that is sought to be established by such means, even to the extent of the actual production of a new species—and nothing of this kind is pretended to—it would leave the question of development by evolution (in the abstract) wholly untouched."

Whether or not this passage has been written after a perusal of the "Variation," it displays an inability to appreciate the function of experiment that to most persons will appear, and rightly appear, lamentable. Comment on so astonishing a passage would be useless, for nothing that I could say could throw its condensed absurdity into any stronger relief. As well might it be said that all our study of electricity is useless for the purpose of furthering our knowledge of natural forces, except so far as observations on the subject are confined to the phenomena of lightning.

Next in order we come upon the writer's estimate of the argument from classification:

The validity of this argument [he says] disappears altogether in view of the fact that just the same state of things would be practicable in the case of a creation according to the vulgar hypothesis of an exercise of the divine power. Considering the mass of animal life to be dealt with, amounting, as just observed, to 120,000 different species, it is almost of necessity that they should be formed upon one or more types or models, implying a certain uniformity of character among the members of the same typical construction, which it is not unreasonable to suppose intended to be evidenced in those animals that were apparently least amenable to it, by the otherwise inexplicable indications of imperfectly developed organs.

Disregarding the error that it is not only in such animals that rudimentary organs are present—seeing that, on the contrary, their occurrence is so general that almost every species presents one or more of them—the idea which is conveyed by this passage is one of the wildest attempts at criticism that I have ever encountered. The instances of affinities in the animal and vegetable kingdoms would, if they could be enumerated, run up into the thousand millions, and extend to the most complex and delicate traits of structure that it is possible to imagine. That such a state of things may be due to intelligent design is a sufficiently reasonable hypothesis, and as such may be properly opposed to the hypothesis of hereditary descent. But the supposition that such a state of things can be due to any "necessity" arising out of "the mass of animal life to be dealt with," is a supposition that could only occur to a mind altogether unacquainted with anatomical science. The marvel always is, not the accidental similarity of organs, due to the exigencies of their performing similar functions, but the adaptation of anatomically homologous organs to the performance of widely different functions. To take only one instance by way of illustration. Where is the "necessity" that no one among the many species of bats should not have the wing formed in any other way than by the highly peculiar and distinctive modification of the hand? Or where is the "necessity" that all the still greater number of species of birds should have their wings formed by another highly peculiar and equally distinctive modification of the arm? Both structures serve equally well for flight; as, indeed, do the wings of insects and did the wings of the pterodactyl. So far, then, as the exigencies arising out of "the mass of animal life to be dealt with" are concerned, there is no reason why these four types of wings should not occur indiscriminately among the four classes of animals in question—and this even if we follow our author in confining the possibilities of creative invention to the anatomical structures of which we are cognizant. This, of course, is but a general refutation. The absurdity of the argument from "necessity" becomes the more apparent the more numerous and more minute the homologies of structure are found to be within the limits of the same type, without ever transgressing on the equally numerous and minute homologies of any other type. But the fact that homologies never thus commingle—that no one of a vast congeries of organs characteristic of one group of organisms ever appears in any other group of organisms—this fact is of such overwhelming force as evidence of genetic descent, that its supposed failure of application in one solitary instance was, as Sir Charles Lyell wisely observed, to his mind the strongest argument against evolution with which he had met. This solitary case of failure had reference to the eye of a mollusk (the cuttle-fish), which was alleged to be anatomically similar to the eye of a true fish. The allegation proved to be wholly false; but, so far as any "necessity" arising from the difficulty of inventing new forms is concerned, there is no reason why the allegation should not have been true.

Our reviewer next treats of the argument from embryology, and in doing so his ideas present that same crudity of cast which gives to his whole essay its grotesque character. He says: "Certainly these remarks are exceedingly curious, and even in a sense imposing. . . . But these resemblances, be they never so close, infer no real connection between the objects thus heterogeneously associated. It is not pretended that the objects compared together are ever entirely alike—that the unborn young of the higher animal is, at any stage of its development, identical with any of the lower animals, but only that some of the features of the one are like the analogous features of the other. . . . That some such resemblance should, in fact, be found to prevail is only what might naturally be expected, considering that each full-grown individual is itself the result of a process of gradual development from a sizeless and shapeless germ, in which development all its organs equally participate," etc. Here, again, we encounter the same argument from "necessity" that has just been considered; and here, again, it is no less preposterous than it was in its previous connection. For to an embryologist nothing could appear more ridiculous than the statement that "in such a case of gradual development it follows, almost as a matter of course, that both the entire animal and all its component members should, in their advance to maturity from a mere *punctum saliens*, exhibit some faint resemblance" to other and allied animals. As a matter of fact, the resemblance is never "faint" but profound, affecting all the structures which constitute the essential framework of the organism. The kind of resemblance on which the reviewer would appear inclined to place most reliance would be a superficial resemblance of specific details. But although even this is supplied by many facts—such as the hair on the unborn child, clothing the body except on the palms of the hands and the soles of the feet, which are also denuded in apes—it is not of so deep a significance to a philosophical mind as are the deeper resemblances of anatomical structure. Hence, even if the unborn young of a higher animal were, "at any stage of its development, identical with any of the lower animals," the fact would not speak so strongly in favor of its derivation from a lower form as does the fact of its passing through a whole series of changes, each stage of which refers, in some point of anatomical significance, to some stage in the existing grade of animal organizations. Actual *identity* is not what the theory of descent with modification would lead us to expect, seeing that, according to this theory, the comparable features usually refer to features that are derived from a common ancestor lower down in a branching stem of descent. In a family tree we may expect the constituent members to inherit in common some peculiarities possessed by their common ancestors, but we do not expect the personal appearance of all the individuals to be identical. Lastly, when we consider the enormous complexity of organisms, the marvel is how the more complicated, in attaining their higher complexity, mimic so closely the anatomical structures of the organisms lower in the scale of complexity. Far from its being "almost a matter of course," it is in the last degree astounding that a vertebrated animal, for instance, should begin its course of development by the same process of yolk-cleavage that occurs in the rest of the animal kingdom, that its first differentiation of body-layers should present the essential anatomical features of the body-layers that characterize the jelly-fish, and so on. In short, when any one at all acquainted with the facts of embryology regards them *en masse*, the last of all notions to enter his mind will be that they must be as they are "almost as a matter of course." Rather will he be constrained to ask, "How can these things be?" and it is fortunate that there is now a voice of authoritative teaching to answer, "Art thou a master in Israel and knowest not?"

Next we come to the argument from geographical distribution. Here the alleged fallacy of evolution is as follows: "If the environment be taken to be the cause of the specific characters of the animals, similar environments ought to be productive of similar species. But this is very far from being the case." This is, perhaps, as good an instance as we have met of our author's inability to view all the area of an extensive problem. His idea of what constitutes an "environment" is about as adequate as the idea of space that a baby shows when it tries to grasp the moon. The following expresses his idea: "If the environment be taken to be the cause of the diversification of the species, how is it that, where the scope for diversity of environment is apparently the least, the greater is the variety of species? We have before observed that there are about 120,000 species of animals; of these more than one half are aquatic, the inhabitants of seas, lakes, and rivers; to which distinction, combined with temperature, the grounds of diversification seem almost exclusively confined." This is really exquisite—so exquisite that it seems a pity to mar its comicality by a prosaic answer. But, even though I may spoil the joke by explaining it, I must at least explain to the author himself how good a joke he has made.

First, then, besides varying in temperature, the ocean, in its different parts, varies somewhat in depth, in the nature of its bottom, the strength of its currents, the degree of its saltness, and its relations to the land. Next, as contrasted with the land, the water on the globe presents an immensely greater—not only area—but cubical capacity for sustaining life. Again, and of still greater importance, it is a matter of fact, whether or not the doctrine of evolution is true, that geology reveals the existence of multitudinous forms of aquatic life as preceding in time the advent of terrestrial life. And, as the theory of evolution supposes that all the latter forms of life are the lineal descendants of the former, it is clear that by the terms of this theory, no less than by those of geological fact, far more *time* has been allowed for the differentiation of aquatic than for that of terrestrial species. Indeed, looking to the degree in which water, as contrasted with land, has thus been favorably handicapped in the time allowed for the production of species, the only wonder is, that the water does not show a greater comparative wealth of specific forms than it does. But, lastly, and most important of all, it is a huge blunder to imagine that an "environment" consists merely in the physical conditions as to medium, climate, etc., to which an organism is exposed. Of far more importance are the innumerably complex relations of the organism to its neighboring organisms, whether of its own or other species, to which must be added the effects of hereditary endowment from a long line of ancestors occupying other and changing environments, to all of which these ancestors must have been structurally adapted. The word "environment" is a term of the most comprehensive kind, embodying, in every case that it is used, an assemblage of conditions presenting an amount of complexity that is not only inconceivable but wholly unnamable. It is nothing less than amazing to find a man at this time of day seeking to argue that environments can not "be the cause of the diversifications of species," on such grounds as that different species flourish in "parts of South Africa and Australia which are wonderfully similar in their soil and climate." Indeed, not to prolong the discussion of nonsense, I will conclude this part of my reply by quoting the sentence with which he concludes his statement of this particular "fallacy of evolution." I do so because, while he appears to think that the question is of so unanswerable a character as to deserve the place of anti-climax in his argument, it really presents as good an example as could anywhere be found of misconception blatant. Here it is: "And then, what is to be said for the multitude of species to be found in the same localities, the same forests, the same jungles, the same lakes, the same streamlets, where there is literally no room for any difference in the environments at all?"

After an *exposé* of ignorance so crass I do not think that I should be performing any useful function by following the writer any further in his luckless flounderings. The rest of his article consists in a trite statement of the facts that species are not producible by artificial selection, and that some specific forms have remained unchanged through long geological epochs—neither of which facts has the smallest tendency to negative the doctrine of descent.

He also devotes a page or two to sustain the theory that the lake-dwellers and other prehistoric men were the "degraded descendants of a civilized ancestry." Of course, in so doing he has no facts to adduce—merely maintaining that "it is just as possible, just as likely, that the artificers in stone, and the dwellers in the caves of the earth, were the degraded descendants of a civilized ancestry, as the barbarous ancestors of a civilized posterity"—forgetting, on the one hand, that, *if* the general theory of evolution be true, this is *not* so possible or *not* so likely; and, on the other hand, that it is a very unfortunate fact for the possibility and the likelihood in question that the "civilized ancestry" should have been so much less fortunate in leaving behind them relics of their existence than have been their "barbarous posterity." Next, he treats of "the distinction and equable distribution of the sexes." This is, indeed, a subject which the theory of evolution has not yet been successful in completely explaining; but our author, by again displaying his ignorance of Mr. Darwin's writings, has not made so strong a case as he might have made. He appears to think it self-evident that over such things "the struggle for life and natural selection must be equally powerless"—a statement which is self-evidently absurd; for, although a man may doubt whether the alleged cause (natural selection) is competent to effect all that Darwinians here suppose, this writer only weakens his own case by showing that he is ignorant of such a cause having been alleged. And no less unfortunate is he when "attending to the suggestions of the mind" in the matter of protective coloring. For, after stating one or two cases of protective coloring, he makes the startling announcement: "Here, then, are examples of the adaptation of the species to the conditions of their existence which can not . . . . be by virtue of any law of nature; for we neither know of any such law, nor can we conceive of any that could produce the effects in question exclusively in the case of the few species alluded to without regard to the multitudes inhabiting the same localities." Here, again, the most charitable supposition we can make is, that the writer has never read the doctrines which he undertakes to criticise. For, if, after having read all the evidence in favor of protective coloring, he could think to dispose of it by so absurd a criticism as this, we must refuse to consign him a place even among those whom he calls "men of reasoning." If three animals—A, B, and C—inhabit the same locality, and if A is protectively colored, while B and C are not, what must we think of the reasoning which from these premises alone definitely concludes that the imitative coloring of A can not conceivably be due to the operation of a natural law? There may be a thousand and one reasons why B and C should not be affected by the law of protective coloring; yet, merely on the ground that all animals in the same locality are not so affected, we are told to conclude that all the thousands of cases in which animals are thus affected constitute no evidence of the operation of a natural law! Did ever our "man of reasoning" hear of a method of reasoning called the method of concomitant variations?

Lastly, the reviewer enlarges upon the absence of paleontological evidence of connecting specific forms; but, as we have already sufficiently gauged his competence to deal with such subjects as the imperfection of the geological record, I will not occupy further space by considering what he says, further than to show by one concluding quotation the truly appalling state of things, which "it can require but little reflection to perceive" would have been the result of organic evolution, had the world been so unfortunate as to have been subject to such a process. "It requires but a very small stretch of thought further to perceive that, so far from such a principle of creation affording reasonable grounds for the inference of the development of the *species*, according to the present intent of the term, the result must have been the absolute exclusion of all *species* whatever—the production of an indiscriminate mass, or rather *mob* of animals, extending in indistinguishable series from one end of the creation to the other."

Here I gladly stop. It is not to be expected that the majority of those who read the criticism can themselves be in a position to estimate the full extent of its impudence; and for this reason I have taken the trouble to show how, as a criticism, it is beneath contempt—useful only as a warning to those whom it concerns to abstain from meddling with any subject which, neither by mental constitution, thought, nor training, are they in the lowest degree competent to treat.—*Fortnightly Review.*

THE INAUGURATION OF ARAGO'S STATUE.

THE statue to Arago recently unveiled at Perpignan is not the first erected to that great astronomer and greater physicist. In 1867 M. Isaac Pereire, then representative of the native place of Arago in the Imperial Chamber of Deputies, erected one at his own expense at Estagel. The inauguration was accompanied by speeches delivered by the generous donor, M. Bertrand, the Perpetual Secretary of the Academy of Sciences, and others. It was stated then that Arago had supported against his own party the construction of the railways by public companies, and had been grossly abused by some of his political friends. Although a political leader, it must be said, to the glory of Arago, that he never was influenced by party considerations. He was always writing, and speaking, and voting according to the *dictamina* of his own judgment. These facts should be remembered, as efforts have been made, in the recent Arago celebration, to degrade him into a mere politician, which never was the case. Arago was made a member of the Provisional Government of France in February, 1848; it was owing to his personal exertion that the abolition decree was proclaimed before the convocation of the National Assembly. It is true that he was appointed in the beginning of May one of the *quinquemvirs* of the Executive Commission. But this Government was overthrown by the popular rising of the end of June, and from that time he abstained from taking any prominent part in politics.

Arago was not rich, his works having been mostly published in the "Annuaire du Bureau des Longitudes" without any copyright, and sold for the benefit of the Bureau, of which he was the most influential member. His paying works were all of them posthumous, and edited by M. Barras, the Perpetual Secretary of the Agricultural Society of France. The sale was not so large as anticipated, and the publisher who purchased the copyright from the inheritors failed. The sale of the "Annuaire" was so large during Arago's lifetime that the Bureau had a profit by it. Since his death it has become necessary to provide special funds for the publication of that useful work.

Arago had no salary at all as director of the Observatory. He was appointed every year by the Bureau, receiving only £200 for his membership. His other salaries were £50 as a member of the Academy of Sciences, £250 as Perpetual Secretary, and when he was lecturing on astronomy, £50. The functions of deputy and member of Municipal Council of Paris being entirely gratuitous, he was no receiver of any other public moneys. Under the republic his membership of the Assembly brought him one pound a day.

From the eloquent *éloge* pronounced by M. Paul Bert at the recent inauguration, we take the following extract: "To contemplate Arago under all the aspects that may attract the admiration of posterity we must think of him as a man of science overturning the Newtonian hypothesis of the emission of light, determining the physical constitution of the sun, explaining the scintillation of the stars, the nature of the aurora borealis, discovering magnetization by currents, the origin of the electric telegraph, extending to all bodies magnetic properties; finally, for I must limit myself to the most prominent points, indicating to the most eminent of his disciples the star still unknown and invisible, whose discovery introduced order among the perturbed planets, and which still remains the most extraordinary mark of the power of human genius. As a professor, again, before three thousand auditors at the Observatory, or in his chair as Perpetual Secretary, writing his incomparable scientific notices, or dictating, when blind, his popular astronomy, always, by speech or by pen, marvelous for his clearness, his accuracy, his power and fullness, elevating all he touched, returning to the astonished inventor his discovery developed and fertilized, sowing broadcast his ideas, and rejoicing when others, friends or foes, were enriched by the precious fruits of his genius. As a scientific historian he excelled Condorcet, equaled Cuvier and Fontenelle, and was characterized above all others by his eagerness to give every one his due, and his jealous love of justice. As an orator he carried into the tribune the vigor and clearness of the scientific chair, vivified by the emotions of master-spirits, and dominating the assembly by his lofty stature, with his beautiful southern head, and his eye full of fire. He was a man, in fact, in whom the will to act was united with the consciousness of power, an intelligence marvelously comprehensive and powerfully creative, so bold and yet so prudent at times that it never committed an error that required to be retracted. Of an ardent but loyal nature, ready for power, but incapable of hatred, and thirsting for justice, a heart sensitive and valiant, sometimes drawn, says a contemporary, to show itself severe to the strong in order to support the weak; a soul austere but a brow serene; a father and citizen worthy of the ancient legends, and able, like Carnot, on quitting life to bear the noble witness, 'My hands are clean and my heart pure.' From the extent of the sketch you may judge what will be the nature of the picture."—*Nature.*

SKETCH OF DR. ASA FITCH.

By E. P. THURSTON.

THERE is in the world a class of men whose characters, labors, and attainments well entitle them to be called great, who are yet so modest in their self-estimate, so unassuming in their knowledge, that those who dwell about them recognize only the common characteristics of average men ; or if, from peculiar ideas and habits, they are found to be different, the difference is accredited them with complacent tolerance. They are so guileless in life, so pure in thought, and withal so generous-hearted, that in ordinary affairs the world holds them at a disadvantage, quietly appropriating the fruits of their labors with little if any sense of obligation. To this class belonged Dr. Asa Fitch, well known in the scientific world as a distinguished entomologist, whose writings and investigations have contributed largely to our present knowledge of American insects.

Dr. Fitch was the descendant of a long line which in this country, in early colonial times, was linked with the Brewsters of the Mayflower, and other distinguished families. He was the second son of the Hon. Asa Fitch, M. D., a man eminent in the medical profession, and equally so in various positions of public trust to which the people called him.

The subject of our sketch was born at Fitch's Point, Salem, Washington County, New York, February 24, 1809. His childhood was passed on a farm, and until twelve years of age he attended the district school. He was then sent to the academy at the neighboring village of Salem, and at about the same time began a journal of the interesting and important events of his daily life, which, with two or three brief lapses, was continued until his death. Early entries in this record betray the possession in a marked degree, even in his boyhood, of keen observing powers, and a rare faculty for accuracy and lucidity of description, characteristics which in later life grew into striking prominence, and gave to his scientific work an exceptional value. He was an unusually studious pupil, and early evinced a preference for the natural sciences, botany first claiming his attention. In his fifteenth year he began, according to a note in his diary, to arrange the botanical collection of his preceptor in classes and orders. His studies at the academy completed, he remained at home until his eighteenth year, engaged a portion of the time as clerk in a neighboring store.

In the spring of 1826 his father sent him to Rensselaer School, at Troy (now the Rensselaer Polytechnic Institute), where he soon became deeply interested in natural history, zoölogy almost immediately awakening his enthusiasm. The bent of his mind toward entomology quickly declared itself, and it was not long before the insects had more or less complete possession. He graduated with honor at the Rensselaer School with the class of 1827, and immediately after, at the instance of his father, began a course of medical studies, attending lectures at the Vermont Academy of Medicine, at Castleton, but still giving much of his time to the study of insects, the observation of which had now become almost a passion. He persevered, however, in the medical course, graduating M. D. in 1829, and afterward attended lectures at Rutgers Medical College, in New York City, concluding his preparation for the profession in the office of the late Dr. March, of Albany. While thus engaged he made industrious use of the libraries of that city so far as they could aid in advancing his knowledge of entomology. Being unable to purchase the books he needed, and determined to possess all the information they contained about the insects of this country, he copied with great accuracy and rapidity, from the various entomological works in both the State and academy libraries, all that had then been written on American insects.

His medical studies terminated, in the capacity of Assistant Professor of Natural History he accompanied the Rensselaer School Expedition of 1830 to Lake Erie, having then just attained his majority. The President of the school, Professor Eaton, regarded him at this time as the best entomologist in the United States, and he was urged by his friends to publish on the subject. He replied that "Sir Walter Scott was above half right, 'Study in youth, and publish in mature life,'" a precept the youthful investigator followed. At the western terminus of the expedition, Dr. Fitch left the party and traveled extensively in the Western States, collecting and analyzing the rare species of insects found in the localities visited. He returned home in the summer of 1831, and almost immediately began the practice of his profession at Fort Miller, New York, having his office with Dr. Tayler Lewis, afterward the distinguished Professor of Greek in Union College.

November 15, 1832, Dr. Fitch married Elizabeth, daughter of John McNeil, of Stillwater, New York, and soon after removed to that place, continuing the practice of the profession he cordially hated, for six years. In 1838 he gave up practice and returned to Salem, to assume the management of his father's business, for which the latter had become incapacitated by ill health. From this time he devoted himself largely to agricultural pursuits, which gave more ample opportunities for investigation in his favorite field, that he was not slow to improve. It is related that he would frequently be seen after a shower, on his hands and knees, searching about for insects and all manner of "creeping things," and would finally return to the house with his tall old hat completely covered inside and out with the writhing victims of his scientific greed. He was nicknamed "The Bug-Catcher" by his neighbors; and so eager became his quest for curious specimens in wood, field, and stream, that many thought him demented, while others declared that he destroyed more grain than his scientific investigations were worth.

At its organization he became identified with the Washington County Agricultural Society, and soon began to give attention to the public need by various contributions to the local journals on economic entomology. In 1845 he published in Dr. Emmons's "American Quarterly Journal of Agriculture and Science" an article of thirteen pages on "Insects of the genus Cecidomyia," in which he described a new species of willow gall-fly, illustrating it by figures of the insect in different stages of growth, and of the excrescence it produces on the willow. This was his first formal entomological essay. Six months later he sent another of thirty pages to the same journal on "The Wheat-Midge," and, in 1846, a third of sixty-three pages on "The Hessian Fly." This was afterward revised and republished in the "Transactions of the New York State Agricultural Society." In 1847 he published a valuable paper on "Winter Insects," of which he was the first to write specifically; and also in the "Transactions" gave an account of the currant-worm and its moth. This paper, beautifully illustrated with colored engravings, was widely copied in foreign scientific journals, and brought its author prominently into notice as a scientific investigator. At this period Dr. Fitch was employed for a time collecting and naming the insects of the State of New York, for the State Cabinet of Natural History. In the Report of the Regents of the University for 1851 he gave a descriptive catalogue of the insects of New York of the order *Homoptera*, in which he named and described a number of new species.

In 1854 Dr. Fitch was appointed New York State Entomologist, and held the position seventeen years, during which period he devoted himself exclusively and most assiduously to scientific work. The little office a few yards from his residence became his workshop, and night and day sent forth light to the world. So close was the watch he kept at the hatching-time of the various larvæ collected, that for a week together he would catch his sleep in an arm-chair, waking at intervals to note the wonderful changes taking place in the insect-life before him. At such times, his meals, and an extra hour after tea to read the news, was all the recreation he allowed himself, and even then his pocket-net was always within reach, to capture any unwary moth or curious beetle whose love of light attracted it to the room. Dr. Fitch was a most devout Christian, and reading the Scriptures and prayer with his family was a daily habit of his life. But even when thus engaged it was not safe for an attractive insect to come in his way. A daughter, the one to whom he was indebted for many of the beautiful drawings which illustrate his writings, relates that on one such occasion when he had the Bible in his hands, and was about to begin reading, a moth of peculiar appearance alighted on the book before him. The ruling passion was too strong for either time or circumstance: glancing about, as if conscious of the incongruity of the proceeding, he quickly seized his net, bagged the curious specimen, and with a half-guilty look proceeded with the reading. The capture was an important one, as the moth proved to be new to science.

While State Entomologist, his correspondence grew so large as to seriously interfere with other work, and he was at last reluctantly compelled to answer only such letters as were of most importance, devoting the remaining time to research and the preparation of his annual reports. These reports, of which there were thirteen in all, were published in the "Transactions of the State Agricultural Society"; the first nine being also issued in three bound volumes, which were widely circulated both here and abroad, and attracted very favorable attention. His researches were thus brought to the knowledge of foreign entomologists, their value promptly recognized, and the Doctor was soon enrolled as corresponding member of several foreign entomological societies, and later became the recipient of their diplomas, medals, and other testimonials of the appreciation in which his work was held.

The great entomologists of Europe—Westwood and Curtis, of London; Dr. Signoret, of Paris; Dr. Gerstacker, of Berlin; Baron d'Osten-Sacken, of St. Petersburg—were quick to avail themselves of his discoveries, not only by gleaning from his published works, but through the avenue of personal correspondence. His portfolios of foreign correspondence are literally filled with letters of inquiry and acknowledgment from such noted specialists as Dr. Sickel, M. Selys de Lonchamp, and the Abbé Marseul, of France; Professor Boheman, of Sweden; M. Malde, of Germany; and Andrew Murray, of Edinburgh, together with many others of equal reputation.

The success Dr. Fitch achieved was not in any sense the result of favoring circumstances, but the legitimate outcome of his patience in observation and study—study which was always directed by a well-defined plan to a definite object, which as early as 1840 he thus laid down:

"I have undertaken a very great work, and have laid upon myself a task both hard in the plan and difficult in the execution. To unite in one very limited body the most essential facts of the history of insects; to class them with precision and accuracy in a natural series; to delineate the chief traits in their physiognomy; to trace in a laconic and strict manner their distinctive characters, and follow a course which shall correspond with the progress of the science and the eminent men who have contributed to its advancement; to single out the useful and obnoxious species, those which from their manner of living interest our curiosity; to mark the thousand sources where the knowledge of the original authors may be consulted; to render to Entomology that amiable simplicity which she has had in the times of Linnæus, of Geoffrey, and of the first productions of Fabricius, and yet present her as she is to-day, with all the richness which she has acquired from observation, but without surcharging her with it; to conform her, in one word, to the model which I have under my eyes, the work of Cuvier—such is the end which I have taken upon myself to attain."

Dr. Fitch, to a large extent, accomplished this work; but his published treatises form only a small portion of his labors in that direction. One hundred note-books filled with complete and accurate entomological descriptions still remain on the shelves of his office, nearly or quite ready for the press; and it is much to be regretted that his life went out before he had finally completed and published them, and before he had arranged for the permanent retention in this country of his cabinet of insects.

The position of Dr. Fitch as State Entomologist, and the wide circulation of his published writings, brought to him from all quarters insects of rare and little known species to be named and classified. This, joined to his own untiring energy as a collector, enabled him to fill his cabinet to overflowing with the rarest and least known species of many lands. It is rich in all the orders, and especially so in useful, obnoxious, and curious species; and is probably one of the most valuable collections in this country, and one that it would be impossible to duplicate. As such it should be purchased and retained by the State.

It is impossible to summarize the benefits which scholars of Dr. Fitch's character confer upon the world. But it is safe to assume that they are of incalculable value. It is many millions the richer for Dr. Fitch's researches in the science of entomology, and would have been had he written only of the wheat-midge, the Hessian fly, and the currant-worm.

Dr. Fitch lived to the age of seventy. His life was full of strong, pure manhood—full of such labor and study as few men have physical power to endure—full of the gentleness, the kindliness, and peace which come of well-living, and full of the honors which his labors had earned. He died April 8, 1879, the death of a good man.

EDITOR'S TABLE.

THE SOLAR APPENDAGES.

FROM Professor Langley's address at the Saratoga Scientific Association, on the recent progress of solar physics, which is herewith printed, we get a vivid idea of the rapidity with which knowledge upon this subject has advanced within a very few years. We have found out more about the most conspicuous and familiar object in the universe in the last twenty years than all that was known before put together. A late writer in the London "Times" draws attention to the views now taken in regard to the solar surroundings. He considers that recent observations have tended toward marked agreement in the opinions entertained respecting coronal phenomena, and their relation to the zodiacal light. In presenting the results of observations on the eclipse of 1878 those are first taken which give the luminous effects displayed nearest the sun. Mr. Lockyer's drawing represents the black body of the moon as surrounded by a narrow ring of light, the inner corona. Outside this ring are three projections nearly in the ecliptic, and therefore coinciding with the axis of the zodiacal light. The longest of these projections extended to about one and a quarter of the sun's diameter, or not far from one million miles. General Myer described the corona as showing five radial lines of a golden color, beyond which in the direction of the ecliptic were prolonged bright silver rays. General Myer had observed effects so similar in the eclipse of 1869 as to make probable the inference that the objects extending far away from the sun are not subject to change like the prominences. Mr. Alfred C. Thomas also observed streamers of light extending for about one and a half time the diameter of the moon, and also in the plane of the ecliptic. Professor Cleveland Abbe saw the streamers which other observers had compared to a wind-vane, but he traced them to a much greater distance than they had done. The point of the vane as he saw it reached away from the sun to fully six diameters, or more than five million miles. The breadth of the vane, where it crosses the sun, is almost exactly equal to the solar diameter. On the other side of the sun the double streamer forming the tail of the vane did not extend more than three million miles. He also saw other luminous streaks at right angles with these, but of less breadth and length. Professor Langley saw the coronal light extending farther than the long rays observed by Professor Abbe. He traced it to a distance of twelve diameters of the sun on one side and three on the other. Its extension was in the direction of the ecliptic and the light resembled the zodiacal. At its extreme distance from the sun it was a faint and softly graduated luminosity, and not the separate rays discerned at about half the distance. Professor Newcomb saw a similar luminosity, and traced it to the same distance from the sun that had been assigned by Professor Langley. The results are thus summed up by the "Times" writer:

From a comparison of all the observations the following important conclusions seem established beyond all possibility of doubt or question: Outside the solar sierra, averaging some 6,000 or 7,000 miles in height, comes the prominence region, extending about 100,000 miles from the sun's surface. Outside this comes the inner corona, shining in part with its own light, sometimes coming chiefly from multitudes of solid or liquid bodies in a state of incandescence, sometimes chiefly from glowing vaporous matter. This region extends from 200,000 to 500,000 miles from the sun. Beyond the inner corona is the outer corona as already known and photographed during the eclipses of 1870 and 1871, and extending about a million miles from the sun. But far outside the outer corona there is a region occupied by matter so situated and so illuminated (or possibly self-luminous) as to present the appearance of long rays extending, if we may judge from observations hitherto made, directly from the sun to a distance of 5,000,000 miles. Outside this region again lies another in which, whether by the combination of multitudes of such rays as are seen separately close to the sun or through the presence of matter in other forms, a softened luminosity prevails which during total eclipse can be traced along the zodiac at least 10,000,000 miles from the surface of the sun. Lastly, from observations made during evening twilight in spring and during morning twilight in autumn (at which twilight hours the zodiac near the sun is most nearly upright during the year) we can trace the extension of the zodiacal luminosity seen by Langley and Newcomb, to distances exceeding seven or eight times at least those to which they traced it during total eclipse. Nay, there are reasons for believing that at times this luminosity has been traced to such a distance from the sun as to show that the zodiacal matter extends much farther from him than the orbit of our own earth.

Now, in one sense, the relations here presented are not new. The zodiacal light has been known from the time of Childrey, if not from that of Tycho Brahe. Mathematicians have long seen that it must belong to a solar appendage, rejecting utterly the doctrine advanced by some that it comes from matter traveling round our own earth. Again, the long coronal rays had been very confidently regarded by most mathematical astronomers, and indeed by all who had sufficiently studied the evidence, as belonging to matter near the sun. And though the zodiacal had never before been recognized during totality, and so the gap between the outermost coronal rays and the innermost part of the zodiacal seen during twilight had never been observationally filled up, yet the mind's eye of science had clearly discerned even that portion of the zodiacal. Still the recognition of the whole range of solar surroundings, in such sort that no question can any longer, it should seem, be raised as to their reality, even by those least able to follow scientific reasoning, can not but be regarded as an important step.

CONCERNING HONORS TO SPIES.

Mr. Cyrus W. Field has dedicated a memorial stone to the memory of André. It marks the place of his execution and burial. It was uncovered at noon, October 2d, as nearly as possible at the same hour that André was hanged. But few persons were present, and not a word was spoken by any one.

The monument is a plain polished block of Maine granite, five feet in height and three and one half feet square. On the side toward the west is the following inscription:

"Here died, October 2, 1780, Major John André, of the British Army, who, entering the American lines on a secret mission to Benedict Arnold for the surrender of West Point, was taken prisoner, tried and condemned as a spy. His death, though according to the stern code of war, moved even his enemies to pity, and both armies mourned the fate of one so young and so brave. In 1821 his remains were received at Westminster Abbey. A hundred years after his execution this stone was placed above the spot where he lay, by a citizen of the States against which he fought, not to perpetuate the record of strife, but in token of those better feelings which have since united two nations one in race, in language, and in religion, with the earnest hope that this friendly union will never be broken."

Beneath was the name—

"Arthur Penrhyn Stanley, Dean of Westminster."

On the south side the inscription reads as follows:

"Sunt Lacrymæ rerum et mentem mortalia tangunt."—Virgil. "Æneid," I., 462.

The only other inscription is upon the north side, and is this:

"He was more unfortunate than criminal. An accomplished man and a gallant officer."
George Washington.

An inscription will be placed on the east side next year, the centennial of the execution.

The spot where the monument stands

is about two miles from the Hudson River, and is high ground, overlooking a beautiful country. Mr. Field has purchased thirteen acres of land surrounding it, which he proposes to convert into a park; and, when completed, he will present the property to the citizens of Tappan. The shaft is to be surrounded by an iron railing, and around it at the cardinal points are to be planted four trees, oaks or elms, two English and two American.

The remains of Major André repose with the illustrious dead in Westminster Abbey. They were exhumed and carried to England in 1821 by the Duke of York, who was sent over by the British Government for that purpose.

We are glad that this monument has been erected. It indicates the strengthening and a triumph of the nobler sentiments of civilization and a decline of the intensity of international prejudice. And it is especially fitting that Mr. Cyrus W. Field, to whom we so largely owe that grandest of all unifying agencies among nations, the intercontinental telegraph, should have carried out the spirit of this great work, by doing honor to the memory of an enemy of his country, which has been especially odious for these hundred years. To be sure, André was hanged, but that was merely one of the chances of war. Washington would have been hanged also, if the luck of war had run differently. Is it not time to begin to judge of the merits of men independently of the casualties that happen to befall them? We should be sorry not to go behind the gallows, the cross, and the axe, in estimating the characters of their victims.

But another aspect of the matter is noteworthy: Mr. Field is reported to have said that, if he were granted permission, he would erect a monument to the memory of Nathan Hale, the American spy, who was hanged in the public grounds near Hamilton Park in this city. It would have been especially graceful if Dean Stanley had reciprocated Mr. Field's generosity by taking the initiative as an Englishman in doing honor to the memory of Hale. But that was not necessary. The main thing is the concession that the monument was deserved. No one will deny that the young American who gave his life for his country, and only lamented that he had but one to give, well deserves a monument.

But in thus doing honor to the memory of spies it is important to discriminate between the motives that animate them and the traits of character displayed. The military spy represents his country's side in war, and is justified by the ethics of patriotism. The soldier encounters the chance of an honorable death on the field of battle, but is safe if taken prisoner. The spy, on the other hand, if he fails, is certain of an ignominious death. He takes a deadlier risk than the soldier, and requires a firmer courage to meet it. Let the military spy, therefore, who perils and loses his life, have his posthumous honors, the honors due to courageous, unselfish conduct, on whatever side enlisted.

But there is another class of spies who should be hanged without the benefit of monuments; we mean Sherman's custom-house spies. We have revenue laws so scandalous that the regularly appointed officers are ashamed to enforce them. They shrink from branding all American citizens upon their return home after foreign travel as thieves and swindlers, and so the Government sets spies upon its own officers to see that they carry out our revenue regulations in the full measure of their meanness. These spies, employed by Government in time of peace, from purely sordid considerations on both sides, and who are destitute of every manly impulse, abundantly deserve the ropes they do not get, and the spies that are hanged should not be disgraced by being classed with them.

VENTILATING STOVES.

The season has again come which drives people into their houses to pass a large portion of their time in closed apartments where they can keep warm. But the house so tight as to exclude the cold excludes also the air, so that good warmth is apt to involve bad breathing. There will be renewed complaints of deficient ventilation, and plenty of grounds for them. And as people suffer they will exclaim against the backwardness of the art of ventilating, and wonder that science does not bring forward some satisfactory system of furnishing fresh air and plenty of it to those who are shut up in houses during the cold season. Yet the inventors and constructors are ahead of the people, and already furnish many excellent devices which are not appreciated or used. It is perfectly well known, not only that fresh air ought to be furnished to inhabited apartments, but how much should be furnished in given conditions, and how it may be effectually introduced. The problem was in fact practically solved more than a hundred years ago with the invention of the Polignac fireplace, which not only warmed the room where it was set up, but provided for ventilation by bringing in a stream of air from without through suitable ducts, warming it and then throwing it into the apartment. Various modifications of this contrivance have appeared in the shape of ventilating grates which furnish warm fresh air to occupied rooms. But grates are constantly put into houses now which have no more reference to ventilating arrangements than as if nothing of the kind had ever been thought of. Steam and hot-water apparatus, and furnaces to warm large quantities of air for distribution through buildings, have come into extensive use, by which heat and adequate ventilation are well secured; but, after all, these engines are employed by but a small part of the population. A large proportion of the inhabitants of towns, and the great majority of country people, use stoves for warmth in cold weather. But here, again, we see the same neglect in providing fresh air to breathe that is observable in the current use of grates. Stoves are economical and efficient means of warming, and their use for this purpose must long continue. But they are generally non-ventilating, and give us the worst effects of bad air. They draw off from apartments only the air required for combustion, and which is replaced by more air from without to be used for the same purpose. Then there is complaint again, and with abundant reason, of bad ventilation. It seems to be forgotten that there are such things as ventilating stoves. But they have long been in use. The Franklin stove as originally constructed had a provision for ventilation. Ruttan's "Air Warmer" is a double box-stove, which heats by radiation, and also by air which is brought from without, warmed by passing between the inner and outer plates, and delivered into the apartment. The inventor, however, was so intent upon a "system of ventilation" which implied the adaptation of the house to it, that he failed to make his stoves readily available for ordinary use.

The best contrivance we have seen of this kind is the ventilating stove or fireplace known as the "Fire on the Hearth." This combines the advantages of a stove within the room to warm by radiation, a grate giving an open fire, which is prized by many, and a passage or chamber open below and above through which warm air ascends into the room. An opening in the floor with a duct leading to the outside of the house brings in a supply of fresh air which is passed through the stove, warmed, and streams into the apartment. We have tried this stove, and found it satisfactory, both as a heater and a ventilator. We used one of moderate size, which, as tested by the anemometer, gave from eight to ten thousand cubic feet of air per hour in the room, and thus secured excellent ventilation. The difference between an ordinary stove and this ventilating stove in an occupied apartment was most marked to all the inmates, while to gain its advantages it is only needful to incur the small outlay necessary for bringing in the outer air. Fresh air is happily very cheap, but it must have a channel for introduction. If people will not go to the small trouble and expense required to give it entrance, they should not complain of the difficulties and imperfections of ventilation.

THE WORKS OF PROFESSOR VAUGHAN.

We have received various communications from widely different and distant sources in relation to the reputation and works of the late Professor Daniel Vaughan. Severe animadversions have been passed upon the depreciatory tone of comment that has been indulged in with regard to his personality and life; and there has been inquiry as to where his writings may be obtained. Several suggestions have been made respecting the publication of an edition of the most important and popular of his scientific contributions. A correspondent of Salem, Massachusetts, suggests that a very attractive and valuable volume could be made up by his papers on "The Tides," "The Rings of Saturn," "The Origin and End of the World," "The Advent and Appearance of New Stars," "The Nebular Hypothesis," "The Plurality of Worlds," "The Primitive Earth," "The Ancient Atmosphere," "Physics of the Internal Earth," "Volcanoes," "The Moon," "Revelations of Spectrum Analysis," and "The Catastrophes in Celestial Space."

These are certainly interesting topics, and they were handled by Professor Vaughan not only with the ability of an able expositor, but with the freshness of an independent thinker, who had formed his own opinions upon many of the questions involved. Professor Vaughan, as we, however, understand, left no property to pay for the publication of his works, and whether such a volume can be issued will depend upon how publishers regard the venture, or whether he has any friends sufficiently interested in his memory and productions to coöperate in bringing out a collection of his essays.

LITERARY NOTICES.

Ethics, or Science of Duty. By John Bascom, author of "Principles of Psychology," etc. New York: G. P. Putnam's Sons. Pp. 385. Price, $1.75.

Dr. Bascom has here given us a freshly-reasoned and excellent manual of morals. It is attractively written, and very judicious as an exposition of practical duty.

But the title chosen raises expectations, at the present time, which the work seems to us hardly to fulfill. The author recognizes that the subject he is dealing with belongs among the sciences, and is therefore a branch of improvable or progressive knowledge. He, moreover, admits that there is some force in the claim that ethics requires both a new foundation and a new method. The subject is therefore confessedly in a state of transition, or is undergoing a development such as all sciences experience from a less perfect to a more perfect form. Dr. Bascom does not give sufficient prominence to this fact and its important implications. Had he confined himself merely to summarizing the empirical rules of morality as they have been arrived at in social practice, this objection would be less pertinent; but he goes analytically into the subject, works out its principles, reviews ethical systems, discusses ethical methods, and reasons his way to full conclusions respecting the right and wrong of conduct, and the grounds of moral obligation. The whole subject being thus opened, we think the author should have gone further in the scientific direction than he has seen fit to go. He should have placed his exposition upon a scientific groundwork, or have given the reasons for not doing so. His omission is the more surprising when we observe how far he has actually proceeded in the right direction.

It is sufficiently obvious that ethical method passes to a new stage of development with the establishment of the doctrine of evolution. If evolution be true, the foundations of old systems are subverted, and it is necessary to build anew. When he wrote his late elaborate book on "Methods of Ethics," Mr. Sidgwick could not see that evolution had much to do with the subject. If the doctrine had been developed in the universities, he would have probably found its bearings more important. He has found more in it for his second edition, and will be likely to discover still more for the third. Should he finally be compelled to admit that the relation is fundamental, it will be but another instance, of which the history of science is so full, in which what was at first insignificant comes to be supreme.

Dr. Bascom begins better. His first chapter is on "The Remote or Physical Conditions of Duty"; and if this starting-point of a treatise on morality would have seemed surprising a generation or two ago, still more surprising would have been the considerations he has brought forward in this chapter. It does not require a very long memory to recall the time when evolution in any form and to any degree was visited with universal malediction. It was the one poisonous heresy of thought that could not be too severely denounced. But now we see the able President of an influential university planting this doctrine in the opening chapter of a text-book upon morals! If Dr. Bascom assumes rather than formally avows the doctrine, he is but doing what Professor Marsh says the whole scientific world must henceforth do—assume the theory, and go on. But let the author here speak for himself. He says: "The body has been brought up to its present serviceableness through so protracted a development, and the power of the mind is now so measured by it, and is hereafter to be so much extended by means of it, that a brief survey of this middle term between the spiritual and physical worlds becomes very desirable. . . . This power" (the plastic power of life) "has as many forms as there are kinds of living things. In the higher varieties of animals this plastic power which controls the structure, which receives and transmits tendencies, has been built up into a wonderfully complex and mysterious potency by the entire development of life from its first appearance on the globe. This is plainly true if we accept the theory of evolution with definite or indefinite increments. It is also true, though less manifestly so, if we believe in a series of distinct creations. . . . The first term in this plastic power is an organic one. This has every grade of complexity, from that shown in a globule of protoplasm to that manifested in the human body. In it functions and organs are developed coetaneously, are united into a life increasingly complex and single, are left susceptible to a thousand modifying circumstances, and are transmitted with a full entail of established tendencies." After pointing out the gradations of unfolding life through automatic action, instinct, and the higher complexities of mind, the author says: "Another consideration of utmost moment, in estimating our moral activity in its relations to the physical world, is that of inheritance. The power of to-day is not that of a century since, nor will it be that of a century to come. Nor are these forces, in their transition from one stage to another, inapproachable by man. On the other hand, the stream of descent is flexible at every point, as flexible as it can be and retain its general direction. Physical descent is made up of three laws. The primary and central one is, that all organic powers tend to pass from parent to offspring. There is a momentum in the waters of life by which they flow steadily along the slopes prepared for them. A second law, which directly modifies the first, and without which it would lose much of its beneficence, is, that organs and functions are subject to changes, which changes may be transmitted. A third law, of less significance, yet one of moment, is, that living forms easily revert to a long antecedent state. As the new conditions impressed upon living things, which are shaken off by this atavism, have reference to secondary adaptations, to new circumstances, and, in many cases, to the wants of man, this reversion is virtually a retrogression under feeble progressive forces. . . . New powers and new beauties may arise in the transfer of inheritance under inscrutable causes, and yet may be taken up by heredity and consolidated among more primitive endowments."

Now, having gone so far, we see not how Dr. Bascom could refrain from going further, and carrying out the doctrine to its logical consequences. For, if evolution be true at all, its truth is fundamental; and, if it have any influence upon ethical method, it must be a determining influence. If development be the method of nature, as Dr. Bascom tacitly admits, then must the moral sentiments and faculties of man be a product of it; and, if man's moral attributes have been evolved in immense time by slow experience, if our present morality has been derived from a lower stage by processes that are carrying it to a higher stage, then surely we have upon us the most important of all ethical questions, viz., by what causes and under what conditions is morality growing better? We have forced upon us the problem of the genesis of moral relations—how lower conduct is passing into higher conduct—what are the present imperfections of moral impulse and guidance which may be expected to disappear in the future—and how far is ethical requirement relative to the progress of the social state. It may not detract from the practical value of Dr. Bascom's manual, that these considerations are not pursued with the thoroughness and in the direction implied by his title and commencing chapter; but the failure of the exposition in this respect leaves it open to the charge of not fully representing the present state of ethical inquiry.

Dr. Bascom makes frequent and critical reference to the ethical views of Herbert Spencer as presented in his "Social Statics," published twenty-nine years ago. But it is nowhere stated, as we observe, that this was a transitional work that no longer accurately represents Mr. Spencer's views, and that, because of its unsatisfactoriness, he entered into a more extensive development of the subject, in which the "Principles of Morality" were to be treated after an exhaustive elucidation of the chief sciences that bear upon the subject. If it was worth while to quote Spencer at all—if his views of a generation ago have still sufficient insight to demand critical attention—it would certainly have been proper to state that the author held them so insufficient that he has devoted his life to the task of placing morals upon a sounder and more scientific basis than was possible when his first work was written.

Freedom in Science and Teaching. From the German of Ernst Haeckel. With a Prefatory Note by T. H. Huxley, F. R. S. D. Appleton & Co. Pp. 121. Price, $1.

The collision of two such minds as those of Virchow and Haeckel over the evolution question could not fail to strike fire and create light. Much able discussion has followed, in which certain important aspects of the question have been scanned and sifted with a thoroughness that would hardly have been secured in the absence of conflict. The reply to Virchow that has been called out from Haeckel and fills this volume is an extremely interesting and instructive contribution to the popular literature of the subject.

It needs hardly to be said that in his celebrated address, which has been received with such favor by the non-scientific portion of the public, and by such scientific persons as are dominated by traditional ideas, Virchow took the ground that evolution is an hypothesis not proved, and that therefore it should not be taught in the German schools; that the evidence of anthropology is thus far against the doctrine of the derivation of man from lower forms of life; and, finally, that there is such an affiliation of Darwinistic theories with modern communism as to raise the question whether the state is not justified in interfering for the suppression of a dangerous teaching. For the reply that Professor Haeckel makes to Virchow's charge that evolution is an "unproved hypothesis," we must refer the reader to the book, which is valuable as showing—1. What kind of evidence is required; 2. That it is abundant in quantity; and, 3. That the difficulty with

Virchow is, that he don't understand or appreciate it. In regard to the anthropological objection, Professor Huxley declares in his preface that Virchow is entirely in the wrong. Authority is here opposed to authority; and Huxley asserts that all we know concerning the most ancient men harmonizes with the view that they have originated under the general law of evolution.

In regard to Virchow's attempt to bring evolution into reproach by associating it with communism, Professor Huxley says: "I think I shall have all fair-minded men with me, when I also give vent to my reprobation of the introduction of the sinister arts of unscrupulous political warfare into scientific controversy, manifested in the attempt to connect the doctrines he (Haeckel) advocates with those of a political party which is at present the object of hatred and persecution in his native land."

Professor Haeckel in dealing with this charge says that "those two theories are about as compatible as fire and water," and remarks upon the subject as follows: "With all these empty accusations, as with all the empty reproaches and groundless objections which Virchow brings against the doctrine of evolution, he takes good care in no way to touch the kernel of the matter. How, indeed, would it have been possible, without arriving at conclusions wholly opposed to those which he has declared? For the theory of descent proclaims, more clearly than any other scientific theory, that the equality of individuals which socialism strives after is an impossibility; that it stands in fact in irreconcilable contradiction to the inevitable inequality of individuals which actually and everywhere subsists. Socialism demands equal rights, equal duties, equal possessions, equal enjoyments for every citizen alike; the theory of descent proves, in exact opposition to this, that the realization of this demand is a pure impossibility, and that in the constitutionally organized communities of men, as of the lower animals, neither rights nor duties, neither possessions nor enjoyments, have ever been equal for all the members alike, nor can ever be. Throughout the evolutionist theory, as in its biological branch, the theory of descent—the great law of specialization or differentiation—teaches us that a multiplicity of phenomena is developed from original unity, heterogeneity from original similarity, and the composite organism from original simplicity. The conditions of existence are dissimilar for each individual from the beginning of its existence; even the inherited qualities, the natural "disposition," are more or less unlike; how then can the problems of life and their solution be alike for all? The more highly political life is organized, the more prominent is the great principle of the division of labor, and the more requisite it becomes, for the lasting security of the whole state, that its members should be variously distributed in the manifold tasks of life; and as the work to be performed by different individuals is of the most various kind, as well as the corresponding outlay of strength, skill, property, etc., the reward of the work must naturally be also extremely various. These are such simple and tangible facts that one would suppose that every reasonable and unprejudiced politician would recommend the theory of descent and the evolution hypothesis in general as the best antidote to the fathomless absurdity of extravagant social leveling.

"Darwinism, I say, is anything rather than socialist! If this English hypothesis is to be compared to any definite political tendency—as is, no doubt, possible—that tendency can only be aristocratic, certainly not democratic, and least of all socialist. The theory of evolution teaches that in human life, as in animal and plant life everywhere and at all times, only a small and chosen minority can exist and flourish, while the enormous majority starve and perish miserably, and more or less prematurely. The germs of every species of animal and plant, and the young individuals that spring from them, are innumerable, while the number of those fortunate individuals which develop to maturity and actually reach their hardly-won life-goal is out of all proportion trifling. The cruel and merciless struggle for existence which rages throughout all living nature, and in the course of nature must rage, this unceasing and inexorable competition of all living creatures, is an incontestable fact; only the picked minority of the qualified 'fittest' is in a position to resist it successfully, while the great majority of the competitors must necessarily perish miserably. We may profoundly lament this tragical state of things, but we can neither controvert it nor alter it. 'Many are called, but few are chosen.' The selection, the picking out of these chosen ones, is inevitably connected with the arrest and destruction of the remaining majority. Another English naturalist therefore designates the result of Darwinism very frankly as the 'survival of the fittest.' At any rate, this principle of selection is nothing less than democratic; on the contrary, it is aristocratic, in the strictest sense of the word. If, therefore, Darwinism, logically carried out, has, according to Virchow, an 'uncommonly suspicious aspect,' this can only be found in the idea that it offers a helping hand to the efforts of the aristocrats. But how the socialism of the day can find any encouragement in these efforts, and how the horrors of the Paris Commune can be traced to them, is to me, I must frankly confess, absolutely incomprehensible."

Report of the Geological Survey of Ohio. Vol. III. Geology and Paleontology. Part I. Geology. Published by Authority of the Legislature of Ohio. Columbus: Nevins & Myers, State Printers. 1878.

This volume, the third in the series, fully sustains the high character which the two previous ones gave to this important work. The officers on whom rests the responsibility of the survey are J. S. Newberry, chief geologist; E. B. Andrews and Edward Orton, assistant geologists; T. G. Wormley, chemist; and F. B. Meek, Paleontologist. A corps of local and special assistants have rendered important service. Those of the corps who have contributed reports for the present volume are Messrs. John J. Stevenson, M. C. Read, A. W. Wheat, John Hussey, F. C. Hill, A. C. Lindemuth, J. S. Hodge, and F. Hesser. All of these reports are of a high order, and show in how careful and thorough a manner the work is being done. Reports of surveys of six counties are by the geologist-in-chief, who also contributes an important paper reviewing the general geological structure of the State. This paper is a wonderfully clear statement of the facts brought out by the local surveys, and of the conclusions which they suggest. It is the more interesting from the fact that it reviews conclusions presented in previous reports of the survey which had been criticised by several eminent geologists in other States. Much of the uncertainty which existed as to the age and geological equivalence of the Ohio rocks seems now to be removed. Concerning the Cincinnati uplift it is said that "the Cincinnati axis in Ohio is an anticlinal ridge of which the arched strata of the Cincinnati Group form the core." This uplift formed an elevated ridge through the Upper Silurian, Devonian, and Carboniferous ages. Many of the great deposits thin out on the sloping sides of this elevation. It constituted, indeed, two islands, one in Tennessee, the other in Kentucky and Ohio.

The Cincinnati Group referred to is shown to contain the characteristic fossils of the Hudson River Group, Trenton Limestone, and some which are found in the Black River and Birdseye Groups. But, says Professor Newberry, they are so intermingled as to make it impossible to identify any one of the subdivisions of the Cincinnati Group with either of the Lower Silurian Limestones of the East.

The Oolitic Iron-ore band of the Clinton is in Ohio, sometimes two or three feet in thickness, sometimes it is scarcely more than a ferruginous stain. This is stated to be in no sense a clay iron-stone, as has been suggested. It is a red hematite, and is called dye-stone ore in Tennessee. It is a marine not a marsh deposit, as shown by the fossils present. The iron was probably brought by drainage water from ferruginous districts and deposited.

The Corniferous Limestone in this State is a vast storehouse of fossils. Extensive collections of these will be fully described in Part II., which treats of paleontology. The land-plants found in this limestone at Sandusky and Delaware may have formed part of the luxuriant vegetation that covered the Cincinnati Island in the Devonian age, "the first land flora of which we have any traces in the United States."

Of the Huron Shale, much has been written. It occurs through Central Ohio in a line of outcrop with a maximum thickness of 350 feet. This formation is a nearly homogeneous bituminous shale, containing at least ten per cent. of combustible matter. It is known in the Western States as black shale. Its precise geological horizon has been a subject of debate. The conclusion of the author is that "the Huron Shale of Ohio is made up of the black shales of the Lower Portage and Genesee." This deposit is an interesting one, from the fact that it is the most important source of supply of petroleum in this country, and also that most of the gas-wells of Ohio and Pennsylvania derive thence their supply of carburetted hydrogen.

If space permitted, we would be glad to present the views of Professor Newberry on the buried river channels—evidences of glacial action—clay deposits of the Drift age, and other subjects of interest to the geologist.

The reports of the local surveys by counties and districts are not only valuable to geologists, but are throughout of a thoroughly practical character. These include thirty-four counties of the State, besides reports of the Hocking Valley coal-field, Perry, and portions of Athens, and Hocking Counties, and the Hanging Rock District.

The reports of counties are illustrated by maps and charts, of which there are twenty, while fifty-three illustrations are printed with the text.

In the preface we are informed that Vol. IV., Zoölogy and Botany, is now in the printer's hands, and that Vol. V., Economic Geology, is in progress. Besides these, full and elaborate maps are in course of preparation.

The work has been issued in editions of 20,000 copies—to the honor of Ohio, be it said.

Distribution of Heat in the Spectra of Various Sources of Radiation. By William W. Jaynes, Ph.D. Cambridge, Mass.: University Press. Pp. 24.

This pamphlet is the thesis presented to the Faculty of Johns Hopkins University by the author upon applying for the degree of Doctor of Philosophy. It first gives an account of former experiments to determine the distribution of heat in the spectrum; and then details the author's elaborate experiments for the determination of the result. There is one plate of apparatus and three large plates of the curves of thermal intensity in different parts of the spectral region. He thus sums up the inquiry: "In concluding this paper there is a strong temptation to speculate upon the meaning of the results obtained. That the geometrical form of the curve should be so nearly the same at all temperatures, and of the same *general* form for all substances, is a fact that probably must have an important physical interpretation. Does not the similarity of the curves for different substances show a similarity of movement of the ultimate components of the several substances, and so point to a similarity of ultimate composition of all matter, the slight differences in the grouping of these parts giving rise to the comparatively slight variations from the same form? Certainly this is not proof, but is it not evidence? And is it not probable that the superposition upon the radiations from the ultimate atoms of the radiations from the groupings of these atoms should cause the curve, as a whole, to move slightly to a shorter or longer wave-length, as the weight of a group is lighter or heavier? But I am aware that such speculations are founded on too insufficient data, and I offer these results merely as an experimental contribution to the science of radiant energy."

A Defense of Philosophic Doubt, being an Essay on the Foundations of Belief. By Arthur James Balfour, M. A., M. P. Pp. 355. Price, $3.50.

The object of this book would not be guessed from its title. It would be supposed to imply an argument in favor of skepticism, unbelief, or freethinking, in their customary applications to religious belief. But this is not the author's aim. On the contrary, the work is "a piece of destructive criticism" directed against the foundations of science. According to the author, it is the function of philosophy to give an account of the grounds of all belief and disbelief, and he labors to show that all the assumptions, principles, postulates, and criteria of truth that are usually taken as the basis of scientific knowledge are illusive and indefensible. The independent existence of an external world is denied; Kant, Hamilton, Mill, and Spencer are refuted; and the conclusion is reached that "science is a system of belief which, for anything we can allege to the contrary, is wholly without proof. The inferences by which it is arrived at are erroneous; the premises upon which it rests are unproved." In a closing chapter on "Practical Results," the object of the work is disclosed—it is to harmonize religion and science by showing that religion is, at any rate, as well off for fundamental proofs as science. The conceptions of causality, uniformity, and permanence of order in nature being held as unproved, it is argued that supernatural interferences are logically admissible, and science and religion come into agreement by opening the doors of ancient and modern spiritualism.

The Science of the Bible; or, An Analysis of the Hebrew Mythology, wherein it is shown that the Holy Scriptures treat of Natural Phenomena only. By Milton Woolley, M. D. Chicago: Knight & Leonard. Pp. 613. 8vo. Price, $4.

This elaborate book is alleged by its author to have had the following origin: Impressed by the sentiment that human nature in every age and country is much the same, he inferred that cosmologies and mythologies generally resemble each other. But, if this be so, then the Hebrew mythology is probably like the rest. So the author, after he was turned sixty, studied the Hebrew language to find the key to the Hebrew mythology and the Hebrew Scriptures. He claims to have succeeded, and this volume is the exposition of his view.

His notion is, that the Bible from beginning to end is but a mass of astronomic myths. On the cover of his book is stamped in gilt the old almanac diagram of the twelve constellations of the zodiac. This diagram reappears printed on a card at the close of the book, with a movable index to show the position of the sun throughout the year. Now, the writer claims that the whole Bible is to be interpreted as referring to the phenomena of the year—the changes of seasons, and the movements and places of the sun, moon, planets, etc. Armed with this clew, Dr. Woolley marches deliberately through the Old Testament, taking its narratives, "Creation," "Adam and Eve," "Cain and Abel," "Flood," "Tower of Babel," "Abram and Sarai," all the way through to "Job" and "Jonah," explaining, right and left, that what is really *meant* by these stories is to symbolize natural phenomena, terrestrial and celestial. For example: "'Now when Moses was grown' (i. e., when Aquarius rises heliacally as before the sun) 'he spied an Egyptian smiting a Hebrew, (winter smiting summer), 'and he looked this way and that way, and perceiving himself unseen' (the sun's rays hid him) 'he slew the Egyptian' (i. e., winter was followed by summer). 'But when he went out the second day' (i. e., after he passed the summer solstice) 'he saw two Hebrews' (the two halves of summer) 'striving together.' In attempting to pacify them he was reminded by the first half of summer, which witnessed his act, of his murder the day before, became frightened, and on learning that Pharaoh (the winter sun) intended to slay him, fled into the land of Midian (strife = the point between winter and summer). Here 'he sat down by a well.' Beer-sheba = the end of the *seventh* month, when the 'former rain' begins."

And so everything is construed. This exegesis would get monotonous and tiresome, but the author peppers his text so profusely with sarcasms at the expense of those who hold to the literal interpretation of Biblical narratives that the tediousness of the exposition is somewhat enlivened. The work evinces much ingenuity, great learning, and indomitable perseverance, though whether these accomplishments have been wisely expended in its preparation is perhaps a question.

Nests and Eggs of American Birds. By Ernest Ingersoll. Published in Parts, 50 cents each. Part I. Pp. 24, with Plates. Salem, Mass.: S. E. Casino.

Hitherto there was no American work on the nests and eggs of birds, and information on that subject existed only in detached form in a multitude of publications or in the minds of ornithologists. Mr. Ingersoll has done a valuable service to ornithology by compiling the present work. When completed it will form a handsome volume, beautifully illustrated with tinted lithographs.

The Evidence of the Senses. Inaugural Address before the Poughkeepsie Society of Natural Sciences. By W. G. Stevenson, M. D., President.

Dr. Stevenson has here brought together many illustrations of errors and delusions to which persons are often subject through defective action of the senses or false interpretations of their impressions. The facts are well interpreted and the accompanying comments judicious. He closes with a reference to spiritualism, and insists upon the need that it should be investigated by experts in matters of evidence.

Haeckel's Genesis of Man; or, History of the Development of the Human Race. Being a Review of his Anthropogeny; and embracing a Summary Exposition of his Views, and of those of the Advanced German School of Science. By Lester F. Ward, A. M. Philadelphia: Ed. Stern & Co. Pp. 64.

We have read this able and admirable pamphlet with much pleasure. As a review of the principal works and a condensed exposition of the thought of the great German biologist, it is executed with judgment, and as an introduction to the study of evolution from a point of view with which the public is not generally familiar, it will prove useful and be welcomed by many readers. And to these merits of the *brochure* it must be added that it is clearly, effectively, and at times eloquently written. To any beginner who proposes to enter upon Haeckel's works, we should say, read this first; and that he will not be misled is sufficiently sure from the fact that Haeckel himself testifies to the substantial correctness with which this essay represents his position.

In stating this position, and in estimating Haeckel's claims, the writer inevitably opens the question of the claims of other men, and has to dwell on points of rivalry, priority, and originality. To whom belongs mainly the credit of working out the theory of dissent, or of establishing the doctrine of development? Thus far Mr. Darwin has had a virtual monopoly of the honor; but, while nobody will grudge him a liberal share of it, it begins to be seen that justice has something to do with it, and that there has been a great deal of loose exaggeration of Mr. Darwin's share in the work. Mr. Ward says that "Professor Haeckel is no mere disciple of Darwin," but has independently cultivated a great biological province, which bears directly upon development, but which Darwin hardly touched, viz., the province of embryology, which has for its object the study of transformations. This department Haeckel has made his own, and, as Mr. Ward shows, it furnishes the most impressive and overwhelming proofs of the truth of evolution that are to be gathered from any special source. This subject Mr. Darwin barely touched in his first book.

Mr. Ward recognizes that Darwin was "diplomatic," and there can be no doubt, both that this is true and that it had much to do with the success of the "Origin of Species." In that work he invoked supernatural intervention where his scientific explanations were faulty; and he abstained from applying his theory to man. Haeckel had nothing of this quality; he was simply logical, and applied the law of descent to the human race at the outset. The consequence was, that he was bitterly attacked, not only by anti-Darwinians but also by Darwinians, who charged that "he was more Darwinistic than Darwin himself." Darwin afterward published "The Descent of Man," but Haeckel had to take the first brunt of the opposition in Germany.

In reviewing the history of the subject, Mr. Ward, following Haeckel, credits Erasmus Darwin, Goethe, and Lamarck with the honor of founding the doctrine of evolution. Lamarck's "Philosophie Zoölogique" was published just fifty years before the "Origin of Species," yet Mr. Ward goes so far as to say that every important principle embraced in the latter work is also contained in the former—except the principle of "natural selection." That principle, moreover, had been long recognized, and the doctrine of the fixity of species was undermined. Mr. Darwin and Mr. Wallace independently showed how "natural selection" may give rise to new species.

It would have afforded a still further illustration of the ripeness of thought upon this subject, and increased the equity of Mr. Ward's distribution of honors, if he had stated that, before Mr. Darwin had published at all on the subject, Spencer had drawn up in full detail his prospectus of the evolution philosophy, covering the whole ground, in ten volumes, and that the subsequent contribution of Mr. Darwin did not make it necessary to disturb the order of his work by so much as the introduction of an additional chapter. The new contribution fell into its proper place in an already organized body of thought.

Easy Lessons in Popular Science. By James Monteith. New York: A. S. Barnes & Co. Pp. 252. Price, $1.

This is a very mixed book, as it treats of almost everything pertaining to air, land, and water. There is a good deal of geography, and something about ships, machinery, plants, animals, etc., etc., with maps and numerous woodcuts drawn in outline with a view to being copied by pupils upon the blackboard. The book can no doubt be made useful in the hands of judicious teachers, and the drawing exercises for which it provides are a good feature; but we do not think that its leading topics are the best to begin with in early science teaching, and it does not sufficiently provide for the direct study of things themselves.

Hints toward a National Culture for Young Americans. By S. S. Boyce. New York: E. Steiger. Pp. 69.

The author's object here is to recommend and enforce a practical system of industrial education for American youth. He points out the deficiencies of the present modes of popular culture, and is favorable to the Kindergarten as a foundation in primary instruction.

Scientific Lectures. By Sir John Lubbock. London and New York: Macmillan & Co. Pp. 187. Price $2.50.

Of this book, we *must* speak of Macmillan's part first. Paper, type, printing, and illustrations are elegant, so that to read it is a luxury. It is such a book as an English baronet might with graceful propriety present to his friends. Imported into this country, it comes rather expensive, considering the amount of its contents; but, happily, they are not of a sort that makes it necessary for anybody to procure the volume. Yet Sir John's lectures are very pleasant reading. He discourses of flowers, plants, and insects, and of the habits of ants, and gives us a great deal of curious and interesting information on those matters which he has made a special study. The fifth and sixth lectures are on "Prehistoric Archæology," and epitomize the views developed in the author's larger works, "Prehistoric Times" and "On the Origin of Civilization."

Science Lectures at South Kensington. Vol. II. Macmillan & Co. Pp. 344. Price, $1.75.

This volume, like the one that preceded it, is filled with good, solid work. There is no attempt at extreme simplification, and not a word for effect; but each lecturer has aimed to make a sound, instructive presentation of his subject. The names are strong, and the subjects well chosen. President Spottiswoode treats of "Polarized Light"; Professor Forbes of "Thermal Conductivity" and "Thermo-Dynamics"; H. W. Chisholm of "Balances"; Professor Pigot of "Geometrical and Engineering Drawing"; Froude of "The Laws of Fluid Resistance"; Dr. Siemens of "The Bathometer"; Burrett of "Sensitive Flames"; Pigot of "Lighthouse Illumination"; Burdon-Sanderson of "Apparatus for Physiological Investigation"; Lauder Brunton of "Apparatus for Physiological Chemistry"; Macleod "On Audiometers"; and Roscoe on "Technical Chemistry."

Zoölogy of the Invertebrate Animals. By Alexander Macalister, M. D. Specially revised for America by A. S. Packard, Jr., M. D. Pp. 143. Price, 60 cents.

This volume belongs to Holt's series of handbooks which claim to be intermediate between the larger text-books and the so-called "primers." In what way the American editor has "revised" the English work for use in this country is not explained, nor does it much matter; the book is well adapted to introduce pupils into the study of zoölogy, as it will attract and interest them. The information furnished has been selected with good judgment, and is no doubt entirely trustworthy.

PUBLICATIONS RECEIVED.

The Young Folks' Cyclopædia of Common Things. By John D. Champlin, Jr. With numerous Illustrations. New York: Holt & Co. 1879. Pp. 695. $3.

Key to the Universe, or a New Theory of its Mechanism. By Orson Pratt, Sen. Salt Lake City: The Author. 1879. Pp. 118. $1.50.

Primitive Manners and Customs. By J. A. Farrer. New York: Holt & Co. 1879. Pp. 345.

The Value of Life: Reply to Mallock's Essay "Is Life worth Living." New York: Putnam's Sons. 1879. Pp. 253. $1.50.

Illustrated Dictionary of Scientific Terms. By William Rossiter. New York: Putnam's Sons. Pp. 350. $1.75.

Wonders of the Flora. By H. A. Kresken. Dayton, O. 1879. Pp. 204. $1.50.

The Rosicrucians, their Rites and Mysteries. By Hargrave Jennings. With numerous Illustrations. New York: J. W. Bouton. 1879. Pp. 388.

Report of the Commissioner of Education for the Year 1877. Washington: Government Printing-Office. 1879. Pp. 850.

First Step in Chemical Principles. By H. Leffmann, M. D. Philadelphia: E. Stern & Co. 1879. Pp. 52. 50 cents.

Ancient Pagan and Modern Christian Symbolism. By Thomas Inman, M. D. With Illustrations. New York: J. W. Bouton. 1880. Pp. 147.

Lessons in Inorganic Chemistry. By W. G. Valentin. With Illustrations. New York: Putnam's Sons. 1879. Pp. 186. $1.

Report on Copper-Tin Alloys. By R. H. Thurston. Washington: Government Printing-Office. 1879. Pp. 300.

Local Government. By R. P. Porter. From "Princeton Review." Pp. 24. 5 cents.

The Public Library and the Common Schools. By C. F. Adams, Jr. Boston: Estes & Lauriat. 1879. Pp. 52. 25 cents.

The South Pass Jetties. By M. E. Schmidt. From "Transactions of the American Society of Civil Engineers." Pp. 36, with Plates.

Address to the New Orleans Sanitary Association. By Dr. J. H. Rauch. Pp. 13.

Domestic Sanitation. New Orleans: Graham Print. 1879. Pp. 20.

Milk and Dairies in New Orleans. New Orleans: Rivers Print. Pp. 16.

Tracheotomy with Galvano-Cautery. By Dr. W. A. Byrd. From "St. Louis Clinical Record." Pp. 7.

Shall the Metric System be made compulsory? By H. T. Blake. From "The New-Englander." Pp. 22.

Petroleum. By P. Schweitzer. Columbia, Mo.: "Statesman" Print. 1879. Pp. 64.

Report of the Entomologist. By C. V. Riley. Washington: Government Printing-Office. 1879. Pp. 52, with Plates.

Phenol. By David Cerna. From "Philadelphia Medical Times." Pp. 5.

American Industries and the Proposed Franco-American Commercial Treaty. San Francisco: "Alta California" Print. Pp. 211.

History of Massage. By D. Graham, M. D. New York: W. Wood & Co. 1879. Pp. 30.

The Pocasset Tragedy. By W. Denton. Boston: The Author. 1879. Pp. 33.

Biographical Notice of Joseph Henry. By Joseph Lovering. Pp. 11.

Sanitary Condition of Montreal. By F. P. Mackelcan, C. E. Montreal: Lovell Print. 1879. Pp. 41. 10 cents.

The More Common Families of Insects. By L. C. Wooster. Whitewater, Wis.: "Register" Print. 1879. Pp. 52.

POPULAR MISCELLANY.

Experiments with Platinum.—A paper by Mr. Edison, on the behavior of platinum under the influence of the electric current, was read at the last meeting of the American Association by Professor F. R. Upham, the author being absent. Having found that a platinum wire, heated by the electric current and suspended in the air, loses weight in proportion to its mass, its heat, and the length of time during which the current passes through it, Mr. Edison took a platinum wire $\frac{20}{1000}$ of an inch in diameter, and wound it in the form of a spiral one eighth of an inch in diameter and one half inch in length. The two ends of the spiral were secured to clamping-posts, and the whole then covered with a small glass shade. After the spiral had been made incandescent for twenty minutes, the shade opposite to the spiral on both sides was slightly darkened, and after five hours was no longer transparent, a film of the metal having been deposited on it. Mr. Edison is convinced that this effect, namely, the loss of weight in the spiral, is due to *the washing action of the air*, to the wearing away of the surface of the platinum by the impact of the stream of gases upon the highly incandescent surface, and not to volatilization. That this supposition is correct is shown by the very different behavior of platinum wire *in vacuo*. Mr. Edison placed a spiral of platinum in the receiver of a common air-pump, and arranged it so that the current could pass through it while the receiver was being exhausted. At the pressure of two millimetres the spiral was kept incandescent for two hours before the deposit on the glass shade became visible. In another experiment, when the exhaustion was higher, the deposit became visible only after five hours. The same paper contained observations on other phenomena of still greater interest. It has been known for some time that platinum, when long subjected to a high temperature, becomes disintegrated. A platinum wire which has been heated to incandescence for twenty minutes, on being examined under a microscope, is seen to be full of cracks, and appears shrunken. If the current is continued for a considerable time the wire will fall to pieces. Now, Mr. Edison finds that this shrinking and cracking of the wire are due entirely to the expansion of the air in the pores of the metal, and its contraction on the escape of the air. If these air-spaces be previously eliminated, the platinum can be heated to incandescence without disintegration. How this is to be done is best told in Mr. Edison's own words:

"I had made a large number of platinum spirals, all of the same size and from the same quality of wire; each spiral presented to the air a radiating surface of three sixteenths of an inch; five of these were brought by the electric current up to the melting-point, the light was measured by a photometer, and the average light was equal to four standard candles for each spiral just at the melting-point. One of the same kind of spirals was placed in the receiver of an air-pump and the air exhausted to two millimetres; a weak current was then passed through the wire slightly to warm it for the purpose of assisting the passage of the air from the pores of the metal into the vacuum. The temperature of the wire was gradually augmented at intervals of ten minutes until it became red. The object of slowly increasing the temperature was to allow the air to pass out gradually and not explosively. Afterward the current was increased at intervals of fifteen minutes. Before each increase in the current the wire was allowed to cool, and the contraction and expansion at these high temperatures caused the wire to weld together at the point previously containing air. In one hour and forty minutes this spiral had reached such a temperature without melting that it was giving a light of twenty-five standard candles, whereas it would undoubtedly have melted before it gave a light of five candles had it not been put through the above process. Several more spirals were afterward tried, with the same result. One spiral, which had been brought to these high temperatures more slowly, gave a light equal to thirty standard candles. In the open air this spiral gave nearly the same light, although it required more current to keep it at the same temperature. Upon examination of these spirals, which had passed through the vacuum process, by the aid of a microscope, no cracks were visible; the wire had become as white as silver, and had a polish which could not be given it by any other means. The wire had a less diameter than before treatment, and it was exceedingly difficult to melt in the oxyhydrogen-flame. As compared with untreated platinum, it was found that it was as hard as the steel wire used in pianos, and that it could not be annealed at any temperature."

Animal Mounds in the Pyrenees.—An interesting paper was read by Dr. Phené at the last meeting of the British Association, on a discovery of animal mounds in the Pyrenees. The author said that this discovery was, in a great measure, due to the description given by Sir Vincent Eyre in 1869 of a remarkable custom of burning living serpents at a particular spot in the Pyrenees. While investigating the region around this place of immolation, Dr. Phené found in certain directions indications which always accompany animal mounds. The churches abounded in features expressive of the subversion of a pagan faith, of which the serpent or dragon had evidently been the central point. Following the track where these indications were plainest, he had come upon mounds as distinct in resemblance to animal forms as any of the American mounds: they were altogether artificial, and shaped into an appearance of animal outline so real as to seem like life. In the parts forming the heads the chamber had been replaced by an arched chamber of Roman work, in another by a descent of several feet into the body of a small church. On the spire of the best preserved animal mound had been a tumulus in which, the *curé* of the church informed Dr. Phené, had been found several of the most primitive cinerary urns, containing bones, Celtic articles, and above them objects of the Gallo-Roman description, and again above these later or Christian Roman works. One of the most interesting of the latter had been laid aside, and the *curé* sought it out for Dr. Phené among some *débris;* it was the stem of an ancient cross, and on it were sculptured serpents—not in the usual position of subjection to a superior power, but evidently as being in a condition of supremacy; but, as there were also several dead ones represented, it might be that the sculpture figured the condition of the real serpents before and after the ceremony of burning. In the district there were many emblems of the serpent or dragon, and the mounds were distinctly of such a form. On the mountains overlooking these mounds were a number of stone circles, like those so well known in Britain. Dr. Phené promised to give further details in a paper which he was to have read before the Congress of Americanists at Brussels.

Carl Vogt on the Archæopteryx.—The Congress of Swiss Naturalists held its sixty-second annual meeting this year at St. Gall. Professor Carl Vogt delivered one of the public lectures, choosing for his subject the archæopteryx, an animal intermediate between birds and reptiles. Of the archæopteryx there exist only two (fossil) specimens, one of which, that first discovered, is in the British Museum; the other, which is by far the more perfect of the two, was discovered a few years ago at Solenhofen, Germany. It is the property of Dr. Haeberlein, of Pappenheim. It was once fondly hoped that the Emperor of Germany would purchase this treasure and preserve it for the Fatherland; but, as Professor Vogt remarks, a petrified cannon or musket would have found infinitely more favor in that quarter! The naturalists who studied the specimen in the British Museum pronounced this Jurassic animal to be a bird, inasmuch as it had a beak, nails, and feathers. But the Solenhofen archæopteryx proves, undoubtedly, that the animal was a bird-like reptile, of the size of a pigeon, which had both scales and feathers, a beak provided with teeth, armed wings, bird-like feet with nails, and a reptilian tail, consisting of twenty vertebræ.

Stilling the Waves with Oil.—A few months ago we printed some observations on the use of oil as a means of calming a tempestuous sea in cases of danger to mariners. A later number of the journal (Chambers's) from which those observations were quoted contains the official report of a ship-master, whose vessel appears to have escaped disaster through the timely use of oil in a storm. This report was sent to "Chambers's Journal" by Mr. Sprunt, British Vice-Consul at Wilmington, North Carolina. It is as follows:

"British brigantine Gem, of Sackville, New Brunswick, Richardson, master. On the 1st of April last, bound from Wilmington, North Carolina, for Bristol, took a heavy gale of wind about a degree to the eastward of Bermuda, from the south, veering rapidly to the northwest, whence it blew a hurricane for thirty-six hours, with a cross-breaking sea, ship laboring heavily—'started' the after-house and boats, stove lazarette hatch, and took try-sail from the mast. All hands aft in the cabin in case the sea should break over and carry away fore-house. 8 P. M., sea getting worse, the master thought of resorting to the oil experiment, which he had read of in 'Chambers's Journal.' Had a canvas bag prepared, holding about three quarts of kerosene oil, with a rope of six fathoms attached, and kept trailing to windward; the oil leaking through the canvas greatly broke topping sea, and made matters much more favorable for the ship. This was kept up through the night; and at 3 A. M. on the 2d of April the weather began to moderate. The mate, who had himself lashed to the rigging during the whole of his watch, believed with the captain that the resort to the oil saved the ship, as such fearful weather had never during the captain's experience of fourteen years been witnessed by him. A drop of the oil will smooth about four feet circumference of sea. Captain Richardson suggests that a canvas bag to hold about six gallons is the best size, pierced with small holes with a penknife, the holes to be enlarged as the canvas becomes wet and its texture closer."

Petroleum for Steam-making.—A successful exhibition was recently made at Pittsburg of a method of using petroleum as fuel on board steamers. In its main features this new method resembles other methods which have been tried with more or less success—air, steam, and oil-spray being injected into a suitable fire-box. The spray is said to be immediately converted into inflammable gas, becoming a pure, bright, powerful flame, free from smoke. To accomplish this result, the inventor resorts to a very simple contrivance, described as follows in the "Journal of the Franklin Institute": A small hole is drilled into the iron front of the fire-box, and into this passes a tube which branches, as it leaves this point, into two pipes. One of these connects with the boiler itself, and the other with a receptacle containing crude oil. At the junction of these pipes there is an aperture for the admission of atmospheric air. Valves of peculiar construction regulate the quantity of steam or oil admitted to the furnace. Our contemporary gives the following account of the experiment made to test the efficacy of this method of employing petroleum in place of coal: "The little steamer Billy Collins was selected by Mr. Campbell for the test. A preliminary blaze of wood under the boiler raised the small quantity of steam necessary to start the burner into operation. The oil-valve was opened a trifle, the steam-valve ditto. The petroleum trickled into the feed-pipe, was caught up by the steam, and both plunged into the depths of the fire-box, a mass of many-tongued, roaring, brilliant flame. As the pressure of steam increased, this flame grew in fury and intense heat. The needle of the steam-gauge climbed rapidly up the dial, and in twenty minutes the safety-valve blew off at 120 pounds pressure. . . . To ocean-going steamers this device must prove of extraordinary interest. A tank of oil, situated at a remote end of the ship, would hold fuel sufficient for a double trip, and supplant the great coal-bunkers with their attendant dirt."

What Nordenskjöld has done.—A current misapprehension of the work done by Nordenskjöld (pronounced *Nordenshuld*), in his recent memorable voyage, is corrected by the "Pall Mall Gazette." He is supposed to have *discovered* the "Northeast Passage." He has *discovered* nothing, not even the shore along which he sailed. Every part of his route was known before, and the whole coast-line had been laid down by the expeditions which, for more than three hundred years, have penetrated from the east and west, or, descending the great Siberian rivers, have crept along the European and Asiatic arctic shores in boats or in dog-sleds. What Nordenskjöld has actually done is to have sailed, in one continuous voyage and in one ship, from the Atlantic to the Pacific, and to have made *en route* a series of scientific collections and observations such as no other explorer in these seas—unless, perhaps, himself in former voyages—had been able to carry away. Professor Nordenskjöld is sanguine that he has proved the feasibility of the northeast passage for ships during most seasons. This the "Pall Mall Gazette" pronounces too hopeful a view, and assuredly a passage which requires over twelve months for its accomplishment can hardly be called "feasible" in any remunerative sense. But one thing is made clear by this voyage, namely, that the great Siberian rivers drive the ice off the coast during several of the late summer and autumn months, and that the Yenisei and Obi may be reached during average years. So confident is the Russian Government that the products of their Asiatic empire will find their way to European markets by way of the Siberian rivers and the Arctic Sea, that they have already established custom-houses at the entrance to the Yenisei and the Obi.

Effects of Tobacco on the Teeth.—Habitual users of tobacco will draw some comfort from observations made by the author of a paper read before the Odontological Society of London. This writer, Mr. Hepburn, says that the direct action of nicotine on the teeth is decidedly beneficial. The alkalinity of the smoke must necessarily neutralize any acid secretion which may be present in the oral cavity, and the antiseptic property of the nicotine tends to arrest putrefactive changes in carious cavities. The author is inclined to believe that the dark deposit on the teeth of some habitual smokers is largely composed of the carbon of tobacco-smoke. This deposit takes place exactly in those portions where caries is most likely to arise, and on those surfaces of the teeth which escape the ordinary cleansing action of the brush. That tobacco is capable of allaying to some extent the pain of toothache is, he thinks, true—its effect being due not only to its narcotizing power, but also to its direct action on the exposed nerve; and he is inclined to attribute the fact of the comparatively rare occurrence of toothache among sailors in great measure to their habit of chewing.

Distribution of Luminous Power in the Sun's Rays.—With the aid of a new spectrometer based on the optical principle that a light becomes invisible when it is in presence of another light about sixty-four times more brilliant, Professor J. W. Draper has been enabled to prove that all the rays of the sun's light possess the same luminous power. In the prismatic spectrum the luminous intensity is greatest, not in the *yellow* but in the *red;* and this effect is due to the action of the prism, which narrows and as it were condenses the colored spaces more and more as we pass toward the red, increasing the intensity of the light as it does that of the heat. But in the grating or diffraction spectrum the luminous intensity is found by Dr. Draper to be equal in all the visible regions, all the colors being simultaneously obliterated by an "extinguishing light," that is, a light about sixty-four times more brilliant. Dr. Draper describes his new spectrometer in the "American Journal of Science and Arts" for July.

The Wild Cattle of Great Britain.—In a work recently published in England is given an account of the origin, history, and present condition of the wild "white cattle" of Great Britain. The supposed primogenitors of these wild cattle were abundant in the Pleistocene age, both in the British Isles and on the neighboring continent, and in later prehistoric times they still existed, as their fossil remains testify. Advancing to historic times, the author, Rev. John Storer, quotes from Herodotus a passage in which mention is made of "large, ferocious, and fleet white bulls" abounding in the country south of Thrace. Poland, Lithuania, and Muscovy were their last strongholds on the Continent of Europe, and they became extinct there in the fifteenth or sixteenth century. But they have still living representatives in England, the Chillingham herd being the most noted. This herd is kept in the park attached to Chillingham Castle in Northumberland, the residence of Lord Tankerville. The earliest historian on this herd, Mr. Storer says, is Thomas Culley, whose book on "Live Stock," published in 1786, is pretty well known. The date of the inclosing of the park of course would probably indicate the period when the wild cattle were first confined, but there seems to be no clear evidence on this point. As long ago as the year 1692, however, there is direct proof in Mackenzie's "View of the County of Northumberland," published in 1825, that the herd then existed, for among other curious notes given therein are those of William Taylor, the steward of Chillingham: "May, 1692—Beasts in the parke. My lorde's, 16 white wilde beasts," etc. Since that period they have flourished in fluctuating numbers, never increasing very rapidly, but retaining all their wild characteristics. The herd is now generally kept up to about threescore.

Regarding the herd of wild cattle inclosed in Chartley Castle Park, Staffordshire, the property of Earl Ferrers's family, accounts alluding to them show of their existence as far back as 1658. They are more massive in character than their congeners of Chillingham, and are not so wild. From what we gather from this most interesting work, the characteristics of the two herds are such as might lead one to infer the descent of the domestic breed of shorthorns from the Chillingham herd, and the old and almost extinct "long-horn" breed from the Chartley stock. It is a remarkable fact in connection with both these herds that the animals individually are built on perfect lines, and their general *contour* is such that many of our great fat-stock breeders would be glad of such correctly formed frames to work upon.

Of the existing Scotch herds of wild cattle, the only one now found retaining to any great degree its pristine condition is the Hamilton herd in Cadgow Park, Lanarkshire. In 1874 this herd numbered some forty animals.

Other herds have existed, and some half-wild herds still are preserved in a few instances in the British Isles; of all of these Mr. Storer has given most entertaining information.

Circulating Libraries and Contagious Disease.—The question having been raised, at a meeting of the directors of the Chicago Public Library, whether books in circulating libraries may become a means of spreading contagious diseases, a committee was appointed to investigate the subject. Letters of inquiry were addressed by this committee to medical and sanitary experts, also to librarians in different parts of the country, and the replies (nineteen in number) are set forth by a member of the committee in a communication to the "Library Journal." None of the writers of the replies could give any fact falling under his own observation tending to show that a contagious disease was ever imparted by a book from a circulating library, and hence the question had to be discussed simply as one of theory. The doctors differed, of course, some of them asserting the risk of contagion to be great, while others held it to be *nil*. The conclusion reached by the committee is that, "while there may be a possibility that contagious diseases may be transmitted by books of a circulating library, the real danger of such transmission is very small." Nevertheless, they recommend to the directors of the library "to act under the advice of the Commissioner of Health, and adopt such regulations as he had suggested, namely: that he furnish to the library, whenever he thinks proper, a list of the premises infected with contagious diseases, and of their residents; that no books be loaned to such houses until they are reported by the health office to be free from contagious diseases, and that all books returned from such houses during this period be disinfected before they are replaced on the shelves of the library."

Bird-Reasoning.—The first winter after the erection of a telegraph line on the coast of Antrim, Ireland, numbers of starlings migrating from Scotland were found dead or wounded on the roadside, they having, evidently, in their flight in the dusky morning, struck against the wires. Strange to say, during the following and succeeding winters, hardly a death occurred among the starlings on their arrival. The inference drawn from all this by a writer in "Nature" is that "the birds were deeply impressed and understood the cause of the fatal accidents among their fellow travelers, that previous year, and hence carefully avoided the telegraph wires; not only so, but the young birds must also have acquired this knowledge and perpetuated it—a knowledge which they could not have acquired by experience or even by instinct, *unless the instinct was really inherited memory* derived from the parents whose brains were first impressed by it."

Habits of the Thresher-Shark.—Having received a fine specimen of the fox, or thresher-shark, Mr. Frank Buckland sends to "Land and Water" an account of all he has been able to learn concerning the habits of that animal. Premising that what he says has to be taken with many "grains of salt," we subjoin the main points of his communication. This shark, it appears, is called "the thresher," from the power it has, in company with the sword-fish, to destroy a whale, by jumping into the air and striking the whale with its tail, the sword-fish in the mean time striking the whale from beneath. Mr. Buckland has never seen a thresher hunting mackerel, but believes that this shark "rushes into a shoal of these fish, and lays about right and left with his long tail; when the frightened mackerel are endeavoring to fall into their ranks again, the shark has a good opportunity of seizing them one by one." Of the contests between thresher-sharks and whales he gives the following animated account, on the authority of one Captain Hill, and in that worthy skipper's own words: "The thresher-sharks just do serve out the whales. The sea sometimes is all blood. A whale once got under our vessel—the Hurricane—to get away from these threshers, and when she was there we was afraid to throw a rope overboard, almost to walk about, for fear she should chuck her tail and punch a hole in our vessel. She was full length, in water as clear as gin, right under our bottom, and laid as quiet as a lamb for an hour and a half, and never moved a fin. Where they had been a-threshing of her, the sea was just like blood. I have seen these 'ere threshers fly out of the water as high as the masthead, and down upon the whale while the sword-fish was a pricking of him from underneath. There is always two of 'em—one up and one under; and I think they hunt together, and you can see the poor whale blow in great agitation; and I be bound the pair of them don't leave him till they have had their penn'orth out of him. I don't think they leaves him till they kills him."

Cost of the Proposed Lake in Algeria.—M. Roudaire, the engineer in charge of the preliminary surveys for flooding the Algerian shotts (dried up lake-beds), estimates the cost of the proposed work at not exceeding 20,000,000 francs. It is only necessary to cut through the narrow isthmus separating the head of the Gulf of Gabes from the extremity of the shott El-Djerid, to form the proposed sea. In a letter from M. Roudaire to M. de Lesseps, the advantages which may be expected to result from the creation of this new sea are stated to be "an immense amelioration of the climate of Algeria and Tunis, since the moisture caused by the evaporation from the vast expanse of water will be driven by the prevailing southerly winds over these countries, forming a layer of humid atmosphere which will greatly mitigate the intensity of the solar rays and retard the cooling of the earth by radiation during the night. The proposed sea, too, being navigable for ships of the greatest draught, will also open a new commercial route for the districts lying to the south of the Aures and the Atlas range; while watercourses which from the south, west, and north converge toward the shotts, but which are now dry during the greater part of the year, will again become rivers, as they once undoubtedly were, leading ultimately to the fertilization of vast tracts of now desert land on their banks."

On the Antiquity of Man.—Starting from the opinion generally accepted among geologists, that man was on the earth at the close of the Glacial epoch, Professor B. F. Mudge adduces evidence to prove that the antiquity of man can not be less than 200,000 years. His argument, as given in the "Kansas City Review of Science," is about as follows: After the Glacial epoch geologists fix three distinct epochs, namely the Champlain, the Terrace, and the Delta, all supposed to be of nearly equal length. Now, we have in the Delta of the Mississippi a means of measuring the duration of the third of these epochs. For a distance of about two hundred miles of this delta are seen forest-growths of large trees, one over the other, with interspaces of sand. There are ten of these distinct forest-growths, which have begun and ended one after the other. The trees are the bald cypress (*Taxodium*) of the Southern States, and some of them were over twenty-five feet in diameter. One contained over 5,700 annual rings. In some instances these huge trees have grown over the stumps of others equally large; and such instances occur in all, or nearly all, of the ten forest-beds. This gives to each forest a period of 10,000 years. Ten such periods give 100,000 years, to say nothing of the time covered by the interval between the ending of one forest and the beginning of another—an interval which in most cases was considerable. "Such evidence," writes Professor Mudge, "would be received in any court of law as sound and satisfactory. We do not see how such proof is to be discarded when applied to the antiquity of our race. There is satisfactory evidence that man lived in the Champlain epoch. But the Terrace epoch, or the greater part of it, intervenes between the Champlain and the Delta epochs, thus adding to my 100,000 years. If only as much time is given to both those epochs as to the Delta period, 200,000 years is the total result."

The Immensity of the Stars.—We take from "Le Monde de la Science" the following interesting "Considerations on the Stars," by Professor J. Vinot: "It is known that the stars are true suns, that some of them are larger than our own sun, and that around these enormous centers of heat and light revolve planets on which life certainly exists. Our sun is distant from us 38,000,000 leagues, but these stars are distant at least 500,000 times as far—a distance that in fact is incommensurable and unimaginable for us. Viewed with the unaided eye the stars and the planets look alike, that is, appear to have the same diameter. But, viewed through the telescope, while the planets are seen to possess clearly appreciable diameters, the stars are still only mere luminous points. The most powerful of existing telescopes, that of Melbourne, which magnifies 8,000 times, gives us an image of one of our planets possessing an apparent diameter of several degrees. Jupiter, for instance, which, seen with the naked eye, appears as a star of the first magnitude, with a diameter of 45″ at the most, will in this telescope have its diameter multiplied 8,000 times, and will be seen as if it occupied in the heavens an angle of 100°. Meanwhile a star alongside of Jupiter, and which to the eye is as bright as that planet, will still be a simple dimensionless point. Nevertheless that star is thousands of times more voluminous than the planet! Divide the distance between us and a planet by 8,000, and you have for result a distance relatively very small; but divide by 8,000 the enormous number of leagues which represents the distance of a star, and there still remain a number of leagues too great to permit of the stars being seen by us in a perceptible form. In considering Jupiter, or any of the planets, we are filled with wonder at the thought that this little luminous point might hide not only all the visible stars, but a number 5,000 fold greater—for of stars visible to our eyes there are only about 5,000. All the stars of these many constellations, as the Great Bear, Cassiopeia, Orion, Andromeda, all the stars of the zodiac, even all the stars which are visible only from the earth's southern hemisphere, might be set in one plane, side by side, with no one overlapping another, even without the slightest contact between star and star, and yet they would occupy so small a space that, were it to be multiplied 5,000 fold, that space would be entirely covered by the disk of Jupiter, albeit that disk to us seems to be an inappreciable point."

A Scientific Detective.—One of the most remarkable among recent inventions is the induction-currents balance, briefly described as follows in the "Athenæum": "It consists of two induced currents from separate induction coils, which are so equal that they neutralize each other. They are connected with three elements of a Daniell's battery, with a small clock and microphone, and a receiving telephone. If a piece of metal is placed in one of the coils, the balance of the currents is disturbed, and the clock is heard to tick; but if another piece of metal, exactly similar, is placed in the opposite coil, the balance is restored, and silence again prevails." From this brief description it will be understood that in this new instrument the physicist has an exquisitely sensitive test of the molecular constitution of many substances, for it detects the presence of mixtures and alloys, however small the quantity. Hence a scale of qualities may be formed; and if the value of silver be placed at 115° there can be no question that everything that marks 115° must be silver, 52° will be iron, 40° lead, and 10° bismuth; and, further, the instrument is at once affected by magnetism, heat, or strain in the substance under examination, and will indicate even the effect of half a minute's rubbing of a piece of metal between the thumb and finger. The induction-currents balance is a contrivance of Professor Hughes's.

Stained Windows.—The method of constructing stained-glass windows is described as follows in "Chambers's Journal": "The design of the window being determined upon, and the cartoon or full-sized drawing being prepared, a kind of skeleton drawing is made showing only the lines which indicate the shape of each separate piece of glass. It is apparently not generally understood that a window is not one piece of glass, to which are applied the various colors displayed, but a number of small pieces, which are united by grooved lead, which incloses each individual fragment, and that each different color we see is the color of that particular piece of glass, the only painting material employed being the dark-brown pigment used to define the more delicate and minute details. This skeleton or working drawing then passes to the cutting-room, where sheets of glass of every imaginable shade are arranged in racks, each bearing a number, by which a particular tint is known. The drawing being numbered on each separate piece of glass by means of a frame containing small pieces of every shade, and each numbered according to the rack containing the glass of that color, the use of this frame renders unnecessary the tedious process of visiting each rack in search of the particular shade required; the glass is laid bit by bit on the drawing, and each piece is then cut to the required shape by means of a diamond. After the glass is cut, it passes to the painter, who, laying it over the drawing, traces upon it with his brush all the details of features, folds of drapery, foliage, etc., as designed by the artist. But as the action of the weather and the continually varying conditions of the atmosphere would speedily remove every vestige of paint if left in this state, it is necessary to subject the painted glass to the action of heat by placing it for several hours in a kiln, under the influence of which the paint is fused into absolute affinity with the glass, and becomes actually incorporated with its substance. After this burning process, it only remains for the different pieces to be united with the grooved leaden framework which binds the whole together. The places where the leads join are then carefully soldered together, and nothing remains but to thoroughly work over the whole surface with a thick kind of cement, which fills up any interstices between the glass and lead, and renders the whole panel perfectly water-tight and weather-proof."

Assimilative Power of Plants.—In a paper read before the Dublin Royal Society, Dr. C. A. Cameron states the result of a preliminary experiment made by him to determine the possibility of substituting for some of the elements in plants other elements of the same atomicity. A sod was taken from a field in which a crop of the so-called artificial grasses (which are chiefly leguminous plants, and not grasses at all) was just peeping over ground. It was placed in a box, and one half of the plants were watered twice a week with a weak solution of potassium selenate. The total quantity of potassium selenate applied to the plants during four weeks amounted to twenty grammes. The result showed that selenic acid, at least when applied in small quantity, does not injure plants. Secondly, it was found that selenic acid had been absorbed by the plants. To determine this point, the plants were partially dried and boiled in strong nitric acid until thoroughly destroyed. The solution was evaporated to dryness, and the residue was treated with dilute hydrochloric acid, which dissolved it nearly completely. The solution was concentrated and mixed with a saturated solution of sulphurous acid, whereupon the liquid assumed at once a deep, blood-red color, from the separation of selenium. The plants had been carefully washed before being dried. In concluding his paper, Dr. Cameron writes as follows: "I think this experiment proves that selenic acid is not injurious to plants when used in small quantity, and that the acid is taken up and retained by plants, or at least by certain varieties of plants. The experiment, however, did not prove whether or not there was a partial replacement of sulphur trioxide by selenium trioxide or of sulphur by selenium. Having lately become possessed of large quantities of selenium compounds, I propose to grow plants in soil or water free from sulphur in any form, but supplied with potassium and ammonia selenates. Should the results of this proposed experiment prove interesting, I shall do myself the honor of submitting them to the society."

Honey-making in the United States.—The annual production of honey in this country is estimated at about 35,000,000 pounds, and the business of bee-keeping is being rapidly systematized. One firm of wholesale grocers in New York keeps as many as 12,000 swarms; other keepers have often from 3,500 to 5,000 swarms. Arrangements are made with farmers and owners of orchards to allow an apiary of a certain number of swarms to be placed in their grounds. At the distance of three or four miles another apiary is placed with another farmer, and so on. For this accommodation the bee-keepers pay either in money or in shares. It is estimated that on an average an acre will support twenty-five swarms, yielding fifty pounds of honey each. The apiaries are cared for by men in the employ of the bee-owners. Many ingenious contrivances have been introduced for the purpose of saving the labor of the bees and the keepers. About ten years ago a German suggested that thin, corrugated sheets of wax, which he called "artificial tablets," should be provided for the bees to make their comb from. These, however, did not come into general use; but a few years ago Mr. W. M. Hoge effected an improvement by starting the side-walls of the cells. When these "foundations," as they are called, were presented to the bees, the intelligent little creatures at once took advantage of them, and extended the side-walls so as to form the regular hexagonal cell. The machine by which the impression is made on both sides of the wax is very simple, and somewhat resembles a clothes-wringing machine, only the iron rollers are studded with little hexagonal-headed pins just the size of the section of a cell, so that, when the thin sheet of wax is pressed up between the pegs to the height of about one sixteenth of an inch, it offers a substance for the construction of the cell-walls. Another remarkable adaptation of machinery is afforded by the use of a rotating frame, which causes the cells of the comb placed in it to be emptied by centrifugal force. The empty, uninjured comb is afterward replaced in the hive, and again used by the bees. As about three fourths of the time of the bees, it has been computed, is taken up in the construction of the comb, it will be seen that by these contrivances a great saving of bee-labor is effected.

Brain-Texture and Mental Make-up.—The members of the Paris Anthropological Society were not a little surprised by the tenor of a report made by M. Thulié upon the appearance of the brain and cranium of M. Asseline, one of their fellows, lately deceased, at the age of forty-nine. M. Asseline belonged to a "society for mutual autopsy," and the examination of his brain was made by his bereaved *cosocietaires*, who were prepared to find in it all the commonly received external indications of a highly refined and intellectual nature. He had been a republican and a materialist; possessed enormous capacity for work, great faculty of mental assimilation, and an extraordinarily retentive memory; had a gentle, kindly disposition, keen susceptibilities, refined taste, and subtile wit. As a writer he had always displayed great learning, unusual force of style, and elegance of diction; and in his intercourse with others he had been unassuming, sensitive, and even timid. But "the autopsy showed," says "Nature," "such coarseness and thickness of the convolutions that M. Broca presumed them to be characteristic of an inferior brain. The fossæ or depressions regarded by Gratiolet as of a simian character, and as a sign of cerebral inferiority, which are often found in women, and in some men of undoubted intellectual inferiority, were very much marked, especially on the left parieto-occipital. But the cranial bones were at some points so thin as to be translucent; the cerebral depressions were deeply marked, the frontal suture was not wholly ossified, a decided degree of asymmetry was manifested in the greater prominence of the right frontal, while, moreover, the brain weighed 1,468 grammes—i. e., about sixty grains above the average given by M. Broca for M. Asseline's age."

NOTES.

The important statement is made by Professor C. V. Riley that for the feeding of silkworms there is no appreciable difference between the leaves of the osage orange and the mulberry, provided care is taken to reject the more tender and milky leaves of the former, as they are apt to produce flaccidity and disease.

A writer in "Nature" suggests the employment of carrier-pigeons in the British meteorological service as a means of bringing accounts of the weather at different points in the Atlantic Ocean 300, 400, or even 500 miles out, the pigeons being dispatched on outward voyages of ships leaving such ports as Queenstown, Southampton, etc. The present great difficulty of the meteorological service of Europe is that storms reach the coast unannounced over the Atlantic.

Upon the publication of Siemens's remarks on conveying to a distance, by means of electricity, the power developed by the Falls of Niagara, several electricians declared the idea to be preposterous. Thus one writer calculated that the thickness of the cable required to convey to the distance of several hundred miles the current which could be produced by the power of Niagara, would require more copper than exists in the whole of the Lake Superior region. Another statement estimates the cost of the cable at about sixty dollars per lineal foot. But calculations made by Professor Elihu Thomson and Edwin J. Houston, of Philadelphia, show that these estimates are erroneous, and that it is possible to convey the total power of Niagara a distance of five hundred miles or more by a copper wire not exceeding one half inch in thickness. Even though in practice this result be unattainable, the important fact still remains that, with a cable of very limited size, an enormous quantity of power may be transferred to considerable distances.

Bernhard von Cotta, the eminent Saxon geologist and Professor of Geology in the University of Freiberg, died at that place September 14th, at the age of seventy-one years. He was an indefatigable student and writer, and his published works are very numerous. His first book, on "The Dendroliths," was written while he was yet a student at Freiberg. Later he was associated with Naumann in preparing the geological map of Saxony. The first volume of his "Geognostic Travels" appeared in 1836, and the second in 1838. One of his principal works, namely the "Introduction to the Study of Geognosy and Geology," first published in 1839, passed through several editions. But his greatest work was undoubtedly his "Geologie der Gegenwart" (The Present State of Geology). This work has passed through five editions. A few of his works have been translated into English and other languages of Europe.

The metal *scandium*, obtained by its discoverer Nilsson from ytterbine, has lately been found by P. Clève in yttrotitanite from Norway. The only oxide of scandium, *scandine*, appears to possess the formula Sc_2O_3. The atomic weight of the new metal is 45. Scandine is a pure white powder, light, infusible, and resembling magnesia. The hydrate of scandium is a white and bulky precipitate like hydrate of alumina. The scandium salts are colorless or white; they have an astringent and very sour taste, very different from the sugary taste of the other yttria earths. Scandium is one of the metals predicted by Mendelejef; he gave it the name of *ekabor*, and fixed its atomic weight at 44. The characters of ekabor correspond pretty closely with those of scandium.

By means of his new spectroscope, with compound sulphide of carbon prisms, M. Thollon has produced a remarkable map of the solar spectrum. This map is no less than ten metres in length, and is composed of about 4,000 lines. M. Thollon has devoted great care to reproducing the physiognomy of each line; and there are many new features revealed which will doubtless be utilized for theory.

The German Empress, Augusta, soon after the death of the young Prince Waldemar, son of the German Crown-Prince, offered a considerable sum of money as a prize for the best essay on "Diphtheria, its Nature and Treatment." A commission of eminent physicians has been appointed, with Dr. von Langenbeck, of Berlin, as chairman, to award the prize. The lists will remain open until December 15, 1880. The competing essays may be written either in German, French, or English.

During the first six months of the present year, regular tides have been observed in the subterranean waters of the Fortschritt mine in Bohemia. This strange phenomenon has attracted the attention of the Academies of Science of Berlin and Vienna, but as yet no adequate explanation of it has been proposed.

A Chinaman was fined ten pounds for "sweeping the streets" in an Australian town. In explanation, it may be mentioned that the streets are metaled with quartz, which is crushed to powder by vehicles, and that the sweepings often give a very lucrative return in gold-washing. Here the gold return is largest when the streets are left unswept!

The Rev. Dr. Barnard, President of Columbia College, New York City, in his last annual report, warmly advocates the co-education of young men and young women in colleges. It is, he says, mainly the spirit of conservatism which opposes the opening of colleges to women, rather than anything inherently objectionable in the proposition itself. That this is so, is made evident by the fact that no such opposition manifests itself to the association of students of both sexes in academies and high-schools, many of which profess to teach the same subjects as the colleges, to the same extent, and to pupils of similar ages.

The historian of civilization in some distant future period will probably quote the following passage from a letter written by a British officer in Zululand, as an illustration of the state of civilization existing in the last quarter of the nineteenth century. This officer writes: "I flatter myself that I put an end to six promising young Zulus. We expected no quarter and gave none. When the fighting was over, some of our native troops were sent out on the errand of dispatching the wounded, many of whom had crawled away into the long grass, and even into the ant-bear holes, but our allies were even with them all round."

At Baku, on the Caspian Sea, the residue (*astalki*) left after the final distillation of petroleum is produced in such enormous quantity that its price is only nominal, and much of it is poured into the sea for lack of stowing space or demand. For years it has been the only fuel used on board the war-ships and mercantile steamers of the Caspian. It is employed in cooking also, and for the production of illuminating gas. In the latter case it is allowed to trickle slowly into retorts raised to a dull-red heat, pure gas with a little graphite being the result. Weight for weight, astalki gives four times as great a volume of gas as ordinary coal.

According to Gerard von Schmitt, physician and traveler, the plant *Mikania guaco* possesses medicinal properties very efficacious in the treatment of cancer and allied diseases.

The following is Hersch's test for sewage contamination, or the presence of putrescible organic matter in water: Fill a clean pint bottle three quarters full with the water to be tested, and in it dissolve half a teaspoonful of the finest sugar; then cork the bottle and set it in a warm place for forty-eight hours. If, meanwhile, the water becomes cloudy or milky, it is unfit for domestic use. If it remains perfectly limpid, it is probably safe to use.

HEINRICH WILHELM DOVE.

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RECENT ANTHROPOLOGY.*

By EDWARD B. TYLOR, D. C. L., F. R. S.

IN surveying modern scientific opinion, the student is often reminded of a doctrine proclaimed in the ancient hymns of the Zend-Avesta, that of *Zrvâna akarana*, or "endless time." Our modern schemes of astronomy, geology, biology, are all framed on the assumption of past time immense in length. In fact, one reason why the latter sciences grew so slowly till almost our own day, was their being shackled by the bonds of a short chronology, allowing no room for the long successive periods through which it is now clear that the earth with its plants and animals passed into their present state. Even the science of man, though concerned with the later forms of being, belonging to times which geologists treat as almost modern, has nevertheless to deal with periods of time extending far back beyond the range of history and chronology.

Looking back four thousand to five thousand years, what is the appearance of mankind as disclosed to us by the Egyptian monuments and inscriptions? Several of the best-marked races of man were already in existence, including the brown Egyptian himself, the dark-white Semitic man of Assyria or Palestine, the Central African of two varieties, which travelers still find as distinct as ever, namely, the black or negro proper, and the copper-colored negroid, like the Bongo or Nyam-nyam of our own time. Indeed, the evidence accessible as to ancient races of man goes to prove that the causes which brought about their differences in types of skull, hair, skin, and constitution, did their chief work in times before history began. Since then the races which had become adapted to their geographical regions may

* Address before the Anthropological Section of the British Association, at Sheffield.

have, on the whole, undergone little change while remaining there, but some alterations are traced as due to migration into new climates. Even these are difficult to follow, masked as they are by the more striking changes produced by intermarriage of races. Now, the view that the races of man are to be accounted for as varied descendants of one original stock is zoölogically probable from the close resemblance of all men in body and mind, and the freedom with which races intercross. If it was so, then the fact of the different races already existing early in the historical period compels the naturalist to look to a prehistoric period for their development to have taken place in. And, considering how strongly differenced are the negro and the Syrian, and how slowly such changes of complexion and feature take place within historical experience, this prehistoric period was probably of vast length. The evidence from the languages of the world points in the same direction. In times of ancient history we already meet with families of languages, such as the Aryan and the Semitic, and as later history goes on many other families of language come into view, such as the Bantu or Caffre of Africa, the Dravidian of South India, the Malayo-Polynesian, the Algonquin of North America, and other families. But what we do not find is the parent language of any of these families, the original language which all the other members are dialects of, so that this parent tongue should stand toward the rest in the relation which Latin holds to its descendants, Italian and French. It is, however, possible to work back by the method of philological comparison, so as to sketch the outlines of that early Aryan tongue which must have existed to produce Sanskrit and Persian, Greek and Latin, German, Russian, and Welsh, or the outlines of that early Semitic tongue which must have existed to produce Assyrian, Phœnician, Hebrew, and Arabic. Though such theoretical reconstructions of parent language from their descendants may only show a vague and shadowy likeness to the reality, they give some idea of it. And what concerns us here is that theoretical early Aryan and Semitic, or other such reconstructed languages, do not bring our minds appreciably nearer to really primitive forms of speech. However far we get back, the signs of development from still earlier stages are there. The roots have mostly settled into forms which no longer show the reasons why they were originally chosen, while the inflections only in part preserve traces of their original senses, and the whole structure is such as only a long-lost past can account for. To illustrate this important point, let us remember the system of grammatical gender in Greek or German, how irrationally a classification by sex is applied to sexless objects and thoughts, while even the use of a neuter gender fails to set the confusion straight, and sometimes even twists it with a new perversity of its own. Many a German and Frenchman wishes he could follow the example of our English forefathers who, long ago, threw overboard the whole worthless cargo of grammatical gender. But, looking at gender in the ancient grammars, it must be remembered that human custom is hardly ever willfully absurd, its unreasonableness usually arising from loss or confusion of old sense. Thus it can hardly be doubted that the misused grammatical gender in Hebrew or Greek is the remains of an older and reasonable phenomenon of language; but, if so, this must have belonged to a period earlier than we can assign to the theoretical parent language of either. Lastly, the development of civilization requires a long period of prehistoric time. Experience and history show that civilization grew up gradually, while every age preserves recognizable traces of the ages which went before. The woodman's axe of to-day still retains much of the form of its ancestor—the stone celt in its wooden handle; the mathematician's tables keep up in their decimal rotation a record of the early ages when man's ten fingers first taught him to count; the very letters with which I wrote these lines may be followed back to the figure of birds and beasts and other objects drawn by the ancient Egyptians, at first as mere picture-writing, to denote the things represented. Yet, when we learn from the monuments what ancient Egyptian life was like toward five thousand years ago, it appears that civilization had already come on so far that there was an elaborate system of government, an educated literary priesthood, a nation skilled in agriculture, architecture, and metal-work. These ancient Egyptians, far from being near the beginning of civilization, had, as the late Baron Bunsen held, already reached its half-way house. This eminent Egyptologist's moderate estimate of man's age on the earth at about twenty thousand years has the merit of having been made on historical grounds alone, independently of geological evidence, for the proofs of the existence of man in the Quaternary or mammoth period had not yet gained acceptance.

My purpose in briefly stating here the evidence of man's antiquity derived from race, language, and culture, is to insist that these arguments stand on their own ground. It is true that the geological argument from the implements in the drift-gravels and bone-caves, by leading to a general belief that man is extremely ancient on the earth, has now made it easier to anthropologists to maintain a rationally satisfactory theory of the race-types and mental development of mankind. But we should by no means give up this vantage-ground, though the ladder we climbed by should break down. Even if it could be proved that the flint implements of Abbeville or Torquay were really not so ancient as the pyramids of Egypt, this would not prevent us from still assuming, for other and sufficient reasons, a period of human life on earth extending many thousand years further back.

It is an advantage of this state of the evidence that it to some extent gets rid of the "sensational" element in the problem of fossil man, which it leaves as merely an interesting inquiry into the earliest known relics of savage tribes. Geological criticism has not yet absolutely settled either way the claims of the Abbé Bourgeois's flints from

Thénay to be of miocene date, or of Mr. Skertchly's from Brandon to be glacial. The accepted point is, that the men who made the ordinary flint implements of the drift lived in the Quaternary period characterized by the presence of the mammoth in our part of Europe. More than one geologist, however, has lately maintained that this Quaternary period was not of extreme antiquity. The problem is, at what distance from the present time the drift-gravels on the valley-slopes can have been deposited by water-action up to one hundred feet or so above the present flood-levels? It does not seem the prevailing view among geologists that rivers on the same small scale as those at present occupying mere ditches in the wide valley-floors could have left these deposits on the hillsides at a time when they had not yet scooped out the valleys to within fifty or a hundred feet of their present depth. Indeed, such means are insufficient out of all proportion to the results, as a mere look down from the hill-tops into such valleys is enough to show. Geologists connect the deposit of the high drift-gravels with the subsidence and elevation of the land, and the powerful action of ice and water at the close of the Glacial age; and the term "Pluvial period" is often used to characterize this time of heavy rainfall and huge rivers. It was then that the rude stone implements of palæolithic man were imbedded in the drift-gravels with the remains of the mammoth and fossil rhinoceros, and we have to ask what events have taken place in these regions since? The earth's surface has been altered to bring the land and water to their present levels, the huge animals became extinct, the country was inhabited by the tribes whose relics belong to the neolithic or polished-stone age, and afterward the metal-using Keltic nations possessed the land, their arrival being fixed as previous to 400 B. C., the king of the Gauls then being called by the Romans by the name *Brennus*, which is simply the Keltic word for "king"—in modern Welsh *brenin*. To take in this succession of events geologists and archæologists generally hold that a long period is required. Yet there are some few who find room for them all in a comparatively short period. I will mention Principal Dawson, of Montreal, well known as a geologist in this Association, and who has shown his conviction of the soundness of his views by addressing them to the general public in a little volume, entitled "The Story of the Earth and Man." Having examined the gravels of St. Acheul, on the Somme, where M. Boucher de Perthes found his celebrated drift implements, it appeared to Dr. Dawson that, taking into account the probabilities of a different level of the land, a wooded condition of the country, and greater rainfall, and a glacial filling up of the Somme Valley with clay and stones subsequently cut out by running water, the gravels could scarcely be older than the Abbeville peat, and the age of this peat he estimates as perhaps less than four thousand years. Within this period Dr. Dawson includes a comparatively rapid subsidence of the land, with a partial reëlevation, which left large areas of the lower grounds beneath the sea. This he describes as the geological deluge which separates the post-glacial period from the modern, and the earlier from the later prehistoric period of the archæologists.

My reason for going here into these computations of Dr. Dawson's is, that the date about 2200 B. C., to which he thus assigns these great geological convulsions, is actually within historic times. In Egypt successive dynasties had been reigning for ages, and the pyramids had long been built; while in Babylonia the old Chaldean kings had been raising the temples whose ruins still remain. That is to say, we are asked to receive, as matter of geology, that stupendous geological changes were going on not far from the Mediterranean, including a final plunge of I know not how much of the earth's surface beneath the waters, and yet national life on the banks of the Nile and the Euphrates went on unbroken and apparently undisturbed through it all. To us in this section it is instructive to see how the free use of paroxysms and cataclysms makes it possible to shorten up geological time. Accustomed as we are to geology demanding periods of time which often seem to history exorbitant, the tables are now turned, and we are presented with the unusual spectacle of Chronology protesting against Geology for encroaching on the historical period.

In connection with the question of quaternary man, it is worth while to notice that the use of the terms "primeval" or "primitive" man, with reference to the savages of the mammoth period, seems sometimes to lead to unsound inferences. There appears no particular reason to think that the relics from the drift-beds or bone-caves represent man as he first appeared on the earth. The contents of the caves especially bear witness to a state of savage art, in some respects fairly high, and which may possibly have somewhat fallen off from an ancestral state in a more favorable climate. Indeed, the savage condition generally, though rude and more or less representing early stages of culture, never looks absolutely primitive, just as no savage language ever has the appearance of being a primitive language. What the appearance and state of our really primeval ancestors may have been seems too speculative a question, until there shall be more signs of agreement between the anthropologists, who work back by comparison of actual races of man toward an hypothetical common stock, and the zoölogists, who approach the problem through the species adjoining the human. There is, however, a point relating to the problem to which attention is due. Naturalists not unreasonably claim to find the geographical center of man in the tropical regions of the Old World inhabited by his nearest zoölogical allies, the anthropomorphous apes, and there is at any rate force enough in such a view to make careful quest of human remains worth while in those districts, from Africa across to the Eastern Archipelago. Under the care of Mr. John Evans a fund has been raised for excavations in the caves of Borneo by Mr. Everett, and, though the search has as yet had no striking result, money is well spent in carrying on such investigations in likely equatorial forest regions.

It would be a pity that for want of enterprise a chance, however slight, should be missed of settling a question so vital to anthropology.

While the problem of primitive man thus remains obscure, a somewhat more distinct opinion may be formed on the problem of primitive civilized man. When it is asked what races of mankind first attained to civilization, it may be answered that the earliest nations known to have had the art of writing, the great mark of civilization as distinguished from barbarism, were the Egyptians and Babylonians, who in the remotest ages of history appear as nations advanced to the civilized stage in arts and social organization. The question is, under what races to class them? What the ancient Egyptians were like is well known from the monuments, which show how closely much of the present fellah population, as little changed in features as in climate and life, represent their ancestors of the times of the Pharaohs. Their reddish-brown skin, and features tending toward the negroid, have led Hartmann, the latest anthropologist who has carefully studied them, to adopt the classification of them as belonging to the African rather than the Asiatic peoples, and especially to insist on their connection with the Berber type, a view which seems to have been held by Blumenbach. The contrast of the brown Egyptians with the dark-white Syro-Arabians on their frontiers is strongly marked, and the portraits on the monuments show how distinctly the Egyptian knew himself to be of different race from the Semite. Yet there was mixture between the two races, and, what is most remarkable, there is a deep-seated Semitic element in the Egyptian language, only to be accounted for by some extremely ancient and intimate connection. On the whole, the Egyptians may be a mixed race, mainly of African origin, perhaps from the southern Somauli-land, whence the Egyptian tradition was that the gods came, while their African type may have since been modified by Asiatic admixture. Next, as to the early relations of Babylonia and Media, a different problem presents itself. The languages of these nations, the so-called Akkadian and the early Medic, were certainly not of the same family with either the Assyrian or the Persian which afterward prevailed in their districts. Their connection with the Tartar or Turanian family of languages, asserted twenty years ago by Oppert, has since been further maintained by Lenormant and Sayce, and seems, if not conclusively settled, at any rate to have much evidence for it, not depending merely on similarity of words, such as the term for "god," Akkadian *dingira*, being like the Tartar *tengri*, but also on the similarity of pronouns and grammatical structure by post-positions. Now language, though not a conclusive argument as to race, always proves more or less as to connection. The comparison of the Akkadian language to that of the Tartar family is at any rate *prima facie* evidence that the nations who founded the ancient civilization of Babylonia, who invented the cuneiform writing, and who carried on the astronomical observations which made the name of Chaldean famous for all time, may have been not dark-white peoples like the Assyrians who came after them, but perhaps belonged to the yellow race of Central Asia, of whom the Chinese are the branch now most distinguished in civilization. M. Lenormant has tried to identify among the Assyrian bas-reliefs certain figures of men whose round skulls, high cheek-bones, and low-bridged noses present a Mongoloid type contrasting with that of the Assyrians. We can not, I think, take this as proved, but at any rate in these figures the features are not those of the aquiline Semitic type. The bronze statuette of the Chaldean king called Gudea, which I have examined with Mr. Pinches at the British Museum, is also, with its straight nose and long, thin beard, as un-Assyrian as may be. The anthropological point toward which all this tends is one of great interest. We of the white race are so used to the position of leaders in civilization, that it does not come easy to us to think we may not have been its original founders. Yet the white race, whether the dark-whites, such as Phœnicians or Hebrews, Greeks or Romans, or the fair-whites, such as Scandinavians and Teutons, appear in history as followers and disciples of the Egyptians and Babylonians who taught the world writing, mathematics, philosophy. These Egyptians and Babylonians, so far as present evidence reaches, seem rather to have belonged to the races of brown and yellow skin than to the white race.

It may be objected that this reasoning is in several places imperfect, but it is the use of a departmental address not only to lay down proved doctrines, but to state problems tentatively as they lie open to further inquiry. This will justify my calling attention to a line of argument which, uncertain as it at present is, may perhaps lead to an interesting result. So ancient was civilization among both Egyptians and Chaldeans, that the contest as to their priority in such matters as magical science was going on hotly in the classic ages of Greece and Rome. Looking at the literature and science, the arts and politics of Memphis and of Ur of the Chaldees, both raised to such height of culture nearly five thousand years ago, we ask, Were these civilizations not connected? did not one borrow from the other? There is at present a clew which, though it may lead to nothing, is still worth trial. The hint of it lies in a remark by Dr. Birch as to one of the earliest of Egyptian monuments, the pyramid of Kochome, near Sakkara, actually dating from the first dynasty, no doubt beyond 3000 B. C., and which is built in steps like the seven-storied Babylonian temples. Two other Egyptian pyramids, those of Abu-sīr, are also built in steps. Now, whether there is any connection between the building of these pyramids and the Babylonian towers, does not depend on their being built in stages, but on the number of these stages being seven. As to the Babylonian towers, there is no doubt, for, though Birs-Nimrud is now a ruinous heap, the classical descriptions of such temples, and the cuneiform inscriptions, put it beyond question that they had seven stages, dedicated to the seven planets. As to the Egyptian pyramids, the archæologists Segato and Masi positively state of one step-pyramid of Abur-sīr, that it had seven decreasing stages, while, on the other hand, Vyse's reconstruction of the step-pyramid of Sakkara shows there only six. Considering the ruinous state of all three step-pyramids, it will require careful measurement to settle whether they originally had seven stages or not. If they had, the correspondence can not be set down to accident, but must be taken to prove a connection between Chaldea and Egypt as to the worship of the seven planets, which will be among the most ancient links connecting the civilizations of the world. I hope, by thus calling attention to the question, to induce some competent architect visiting Egypt to place the matter beyond doubt, one way or the other.

While speaking of the high antiquity of civilization in Egypt, the fact calls for remark that the use of iron as well as bronze in that country seems to go back as far as historical record reaches. Brugsch writes in his "Egypt under the Pharaohs," that Egypt throws scorn on the archæologists' assumed successive periods of stone, bronze, and iron. The eminent historian neglects, however, to mention facts which give a different complexion to the early Egyptian use of metals, namely, that chipped flints, apparently belonging to a prehistoric Stone age, are picked up plentifully in Egypt, while the sharp stones or stone knives used by the embalmers seem also to indicate an earlier time when these were the cutting instruments in ordinary use. Thus there are signs that the Metal age in Egypt, as elsewhere in the world, was preceded by a Stone age, and, if so, the high antiquity of the use of metal only throws back to a still higher antiquity the use of stone. The ancient iron-working in Egypt is, however, the chief of a group of facts which are now affecting the opinions of anthropologists on the question whether the Bronze age everywhere preceded the Iron age. In regions where, as in Africa, iron-ore occurs in such a state that it can, after mere heating in the fire, be forged into implements, the invention of iron-working would be more readily made than that of the composite metal bronze, which perhaps indicates a previous use of copper, afterward improved on by an alloy of tin. Professor Rolleston, in a recent address on the Iron, Bronze, and Stone ages, insists with reason that soft iron may have been first in the hands of many tribes, and may have been superseded by bronze as a preferable material for tools and weapons. We moderns, used to fine and cheap steel, hardly do justice to the excellence of bronze, or gun-metal as we should now call it, in comparison with any material but steel. I well remember my own surprise at seeing in the Naples Museum that the surgeons of Herculaneum and Pompeii used instruments of bronze.

It is when hard steel comes in, that weapons both of bronze and wrought iron have to yield, as when the long, soft iron broadswords of the Gauls bent at the first blow against the pikes of Flaminius's soldiers. On the whole, Professor Virchow's remarks in the "Transactions of the Berlin Anthropological Society for 1876," on the question whether it may be desirable to recognize instead of three only two ages, a Stone age and a Metal age, seem to put the matter on a fair footing. Iron may have been known as early as bronze or even earlier, but nevertheless there have been periods in the life of nations when bronze, not iron, has been the metal in use. Thus there is nothing to interfere with the facts resting on archæological evidence, that in such districts as Scandinavia or Switzerland a Stone age was at some ancient time followed by a Bronze age, and this again by an Iron age. We may notice that the latter change is what has happened in America within a few centuries, where the Mexicans and Peruvians, found by the Spaniards living in the Bronze age, were moved on into the Iron age. But the question is whether we are to accept as a general principle in history the doctrine expounded in the poem of Lucretius, that men first used boughs and stones, that then the use of bronze became known, and lastly iron was discovered. As the evidence stands now, the priority of the Stone age to the Metal age is more firmly established than ever, but the origin of both bronze and iron is lost in antiquity, and we have no certain proof which came first.

Passing to another topic of our science, it is satisfactory to see with what activity the comparative study of laws and customs, to which Sir Henry Maine gave a new starting-point in England, is now pursued. The remarkable inquiry into the very foundations of society in the structure of the family, set afoot by Bachofen in his "Mütterrecht," and McLennan in his "Primitive Marriage," is now bringing in every year new material. Mr. L. H. Morgan, who, as an adopted Iroquois, became long ago familiar with the marriage laws and ideas of kinship of uncultured races, so unlike those of the civilized world, has lately made, in his "Ancient Society," a bold attempt to solve the whole difficult problem of the development of social life. I will not attempt here any criticism of the views of these and other writers on a problem where the last word has certainly not been said. My object in touching the subject is to mention the curious evidence that can still be given by rude races as to their former social ties, in traditions which will be forgotten in another generation of civilized life, but may still be traced by missionaries and others who know what to seek for. Thus, such inquiry in Polynesia discloses remarkable traces of a prevalent marriage-tie which was at once polygamous and polyandrous, as where a family of brothers were married jointly to a family of sisters; and I have just noticed in a recent volume on "Native Tribes of South Australia," a mention of a similar state of things occurring there. As to the general study of customs, the work done for years past by such anthropologists as Professor Bastian, of Berlin, is producing substantial progress. Among recent works I will mention Dr. Karl Andree's "Ethnologische Parallelen," and Mr. J. A. Farrer's "Primitive Manners." In the comparison of customs and inventions, however, the main difficulty still remains to be overcome, how to decide certainly whether they have sprung up independently alike in different lands through likeness in the human mind, or whether they have traveled from a common source. To show how difficult this often is, I may mention the latest case I have happened to meet with. The Orang Dongo, a mountain people in the Malay region, have a custom of inheritance that when a man dies the relatives each take a share of the property, and the deceased inherits one share for himself, which is burned or buried for his ghost's use, or eaten at the funeral feast. This may strike many of my hearers as quaint enough, and unlikely to recur elsewhere; but Mr. Charles Elton, who has special knowledge of our ancient legal customs, has pointed out to me that it was actually old Kentish law, thus laid down in law-French: "Ensement seient les chateus de gaulekendeys parties en treis apres le exequies e les dettes rendues si il y est issue mulier en vye, issi que la mort eyt la une partie, e les fitz e les filles muliers lautre partie e la femme la tierce partie."—("In like sort let the chattels of gavelkind persons be divided into three after the funeral and payment of debts, if there be lawful issue living, so that the deceased have one part, and the lawful sons and daughters the other part, and the wife the third part.") The Church had indeed taken possession, for pious uses, of the dead man's share of his own property; but there is good Scandinavian evidence that the original custom before Christian times was for it to be put in his burial-mound. Thus the right of the rude Malay tribe corresponds with that of ancient Europe, and the question which the evidence does not yet enable us to answer, is whether the custom was twice invented, or whether it spread east and west from a common source, perhaps in the Aryan district of Asia.

It remains for me to notice the present state of comparative mythology, a most interesting but also most provoking part of anthropology. More than twenty years ago a famous essay, by Professor Max Müller, made widely known in England how far the myths in the classical dictionary and the story-books of our own lands might find their explanation in poetic nature-metaphors of sun and sky, cloud and storm, such as are preserved in the ancient Aryan hymns of the Veda. Of course it had been always known that the old gods and heroes were in some part personifications of nature—that Helios and Okeanos, though they walked and talked and begat sons and daughters, were only the Sun and Sea in poetic guise. But the identifications of the new school went further. The myth of Endymion became the simple nature-story of the setting Sun meeting Selene the Moon; and I well remember how, at the Royal Institution, the aged scholar, Bishop Thirlwall, grasped the stick he leaned on, as if to make sure of the ground under his feet, when he heard it propounded that Erinys, the dread avenger of murder, was a personification of the Dawn discovering the deeds of Darkness. Though the study of mythology has grown apace in these later years, and many of its explanations will stand the test of future criticism, I am bound to say that mythologists, always an erratic race, have of late been making wilder work than ever with both myth and real history—finding mythic suns and skies in the kings and heroes of old tradition, with dawns for love-tales, storms for wars, and sunsets for deaths, often with as much real cogency as if some mythologist a thousand years hence should explain the tragic story of Mary Queen of Scots as a nature-myth of a beauteous dawn rising in splendor, prisoned in a dark cloud-island, and done to death in blood-red sunset. Learned treatises have of late, by such rash guessings, shaken public confidence in the more sober reasonings on which comparative mythology is founded, so that it is well to insist that there are cases where the derivation of myths from poetic metaphors is really proved beyond doubt. Such an instance is the Hindoo legend of King Bali, whose austerities have alarmed the gods themselves, when Vâmana, a Brahmanic Tom Thumb, begs of him as much land as he can measure in three steps; but when the boon is granted, the tiny dwarf expands gigantic into Vishnu himself, and striding with one step across the earth, with another across the air, and a third across the sky, drives the king down into the infernal regions, where he still reigns. There are various versions of the story, of which one may be read in Southey; but in the ancient Vedic hymns its origin may be found when it was not as yet a story at all, only a poetic metaphor of Vishnu, the Sun, whose oft-mentioned act is his crossing the airy regions in his three strides. "Vishnu traversed (the earth), thrice he put down his foot; it was crushed under his dusty step. Three steps hence made Vishnu, unharmed preserver, upholding sacred things." Both in the savage and civilized world there are many myths which may be plainly traced to such poetic fancies before they have yet stiffened into circumstantial tales; and it is in following out these, rather than in recklessly guessing myth-origins for every tradition, that the sound work of the mythologist lies. The scholar must not treat such nature-poetry like prose, spoiling its light texture with too heavy a grasp. In the volume published by our new Folk-Lore Society, which has begun its work so well, Mr. Lang gives an instance of the sportive nature-metaphor which still lingers among popular story-tellers. It is Breton, and belongs to that wide-spread tale of which one version is naturalized in England as "Dick Whittington and his Cat." The story runs thus: The elder brother has the cat, while the next brother, who has a cock left him, fortunately finds his way to a land where (there being no cocks) the king has every night to send chariots and horses to bring the dawn; so that here the fortunate owner of Chanticleer has brought him to a good market. Thus we see that the Breton peasant of our day has not even yet lost the mythic sense with which his remote Aryan ancestors could behold the chariots and horses of the dawn. But myth, though largely based on such half-playful metaphor, runs through all the intermediate stages which separate poetic fancy from crude philosophy embodied in stories seriously devised as explanations of real facts. No doubt many legends of the ancient world, though not really history, are myths which have arisen by reasoning on actual events, as definite as that which, some four years ago, was terrifying the peasant-mind in North Germany, and especially in Posen. The report had spread far and wide that all Catholic children with black hair and blue eyes were to be sent out of the country, some said to Russia, while others declared that it was the King of Prussia who had been playing cards with the Sultan of Turkey, and had staked and lost forty thousand fair-haired, blue-eyed children; and there were Moors traveling about in covered carts to collect them; and the schoolmasters were helping, for they were to have five dollars for every child they handed over. For a time the popular excitement was quite serious: the parents kept the children away from school and hid them, and when they appeared in the streets of the market-town the little ones clung to them with terrified looks. Dr. Schwartze, the well-known mythologist, took the pains to trace the rumor to its sources. One thing was quite plain, that its prime cause was that grave and learned body, the Anthropological Society of Berlin, who, without a thought of the commotion they were stirring up, had, in order to class the population as to race, induced the authorities to have a census made throughout the local schools, to ascertain the color of the children's skin, hair, and eyes. Had it been only the boys, to the Government inspection of whom for military conscription the German peasants are only too well accustomed, nothing would have been thought of it; but why should the officials want to know about the little girls' hair and eyes? The whole group of stories which suddenly sprang up were myths created to answer this question; and even the details which became embodied with them could all be traced to their sources, such as the memories of German princes selling regiments of their people to pay their debts, the late political negotiations between Germany and Russia, etc. The fact that a caravan of Moors had been traveling about as a show accounted for the covered carts with which they were to fetch the children; while the schoolmasters were naturally implicated, as having drawn up the census. One schoolmaster, who evidently knew his people, assured the terrified parents that it was only the children with blue hair and green eyes that were wanted—an explanation which sent them home quite comforted. After all, there is no reason why we should not come in time to a thorough understanding of mythology. The human mind is much what it used to be, and the principles of myth-making may still be learned from the peasants of Europe.

When, within the memory of some here present, the science of man was just coming into notice, it seemed as though the study of races, customs, traditions, were a limited though interesting task, which might, after a few years, come so near the end of its materials as no longer to have much new to offer. Its real course has been far otherwise. Twenty years ago it was no difficult task to follow it step by step; but now even the yearly list of new anthropological literature is enough to form a pamphlet, and each capital of Europe has its anthropological society in full work. So far from any look of finality in anthropological investigations, each new line of argument but opens the way to others behind, while these lines tend as plainly as in the sciences of stricter weight and measure toward the meeting-ground of all sciences in the unity of nature.—*Nature*.

ON RADIANT MATTER.*

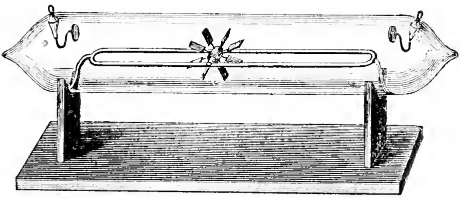
By WILLIAM CROOKES, F. R. S.

II.

Radiant Matter exerts Strong Mechanical Action where it strikes.

We have seen, from the sharpness of the molecular shadows, that radiant matter is arrested by solid matter placed in its path. If this solid body is easily moved, the impact of the molecules will reveal itself in strong mechanical action. Mr. Gimingham has constructed for me an ingenious piece of apparatus which, when placed in

Fig. 11.



the electric lantern, will render this mechanical action visible to all present. It consists of a highly-exhausted glass tube (Fig. 11), hav-

* A lecture delivered before the British Association for the Advancement of Science, at Sheffield, Friday, August 22, 1879.

ing a little glass railway running along it from one end to the other. The axle of a small wheel revolves on the rails, the spokes of the wheel carrying wide mica paddles. At each end of the tube, and rather above the center, is an aluminium pole, so that whichever pole is made negative the stream of radiant matter darts from it along the tube, and striking the upper vanes of the little paddle-wheel, causes it to turn round and travel along the railway. By reversing the poles I can arrest the wheel and send it the reverse way; and if I gently incline the tube, the force of impact is observed to be sufficient even to drive the wheel up hill.

This experiment, therefore, shows that the molecular stream from the negative pole is able to move any light object in front of it.

The molecules being driven violently from the pole, there should be a recoil of the pole from the molecules, and by arranging an apparatus so as to have the negative pole movable and the body receiving the impact of the radiant matter fixed, this recoil can be rendered sensible. In appearance the apparatus (Fig. 12) is not unlike an ordi-

Fig. 12.

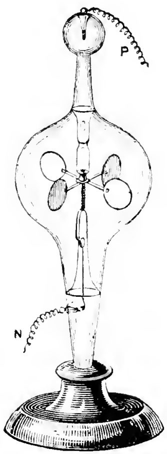
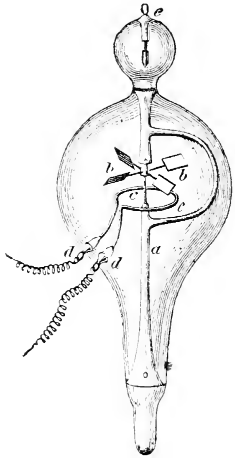


Fig. 13.



nary radiometer with aluminium disks for vanes, each disk coated on one side with a film of mica. The fly is supported by a hard steel instead of glass cup, and the needle-point on which it works is connected by means of a wire with a platinum terminal sealed into the glass. At the top of the radiometer-bulb a second terminal is sealed in. The radiometer, therefore, can be connected with an induction-coil, the movable fly being made the negative pole.

For these mechanical effects the exhaustion need not be so high as when phosphorescence is produced. The best pressure for this electrical radiometer is a little beyond that at which the dark space round the negative pole extends to the sides of the glass bulb. When the pressure is only a few millimetres of mercury, on passing the induction-current a halo of velvety violet light forms on the metallic side of the vanes, the mica side remaining dark. As the pressure diminishes, a dark space is seen to separate the violet halo from the metal. At a pressure of half a millimetre this dark space extends to the glass, and rotation commences. On continuing the exhaustion the dark space further widens out and appears to flatten itself against the glass, when the rotation becomes very rapid.

Here is another piece of apparatus (Fig. 13) which illustrates the mechanical force of the radiant matter from the negative pole. A stem (*a*) carries a needle-point in which revolves a light mica fly (*b b*). The fly consists of four square vanes of thin, clear mica, supported on light aluminium arms, and in the center is a small glass cap, which rests on the needle-point. The vanes are inclined at an angle of 45° to the horizontal plane. Below the fly is a ring of fine platinum wire (*c c*), the ends of which pass through the glass at *d d*. An aluminium terminal (*e*) is sealed in at the top of the tube, and the whole is exhausted to a very high point.

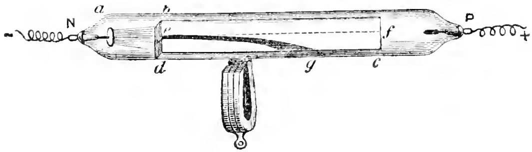
By means of the electric lantern I project an image of the vanes on the screen. Wires from the induction-coil are attached, so that the platinum ring is made the negative pole, the aluminium wire (*e*) being positive. Instantly, owing to the projection of radiant matter from the platinum ring, the vanes rotate with extreme velocity. Thus far the apparatus has shown nothing more than the previous experiments have prepared us to expect; but observe what now happens. I disconnect the induction-coil altogether, and connect the two ends of the platinum wire with a small galvanic battery: this makes the ring *c c* red-hot, and under this influence you see that the vanes spin as fast as they did when the induction-coil was at work.

Here, then, is another most important fact. Radiant matter in these high vacuă is not only excited by the negative pole of an induction-coil, but a hot wire will set it in motion with force sufficient to drive round the sloping vanes.

Radiant Matter is deflected by a Magnet.—I now pass to another property of radiant matter. This long glass tube (Fig. 14) is very highly exhausted; it has a negative pole at one end (*a*) and a long phosphorescent screen (*b*, *c*) down the center of the tube. In front of the negative pole is a plate of mica (*b*, *d*) with a hole (*e*) in it, and the result is, when I turn on the current, a line of phosphorescent light (*e*, *f*) is projected along the whole length of the tube. I now place beneath the tube a powerful horseshoe magnet: observe how the line of light (*e*, *g*) becomes curved under the magnetic influence waving about like a flexible wand as I move the magnet to and fro.

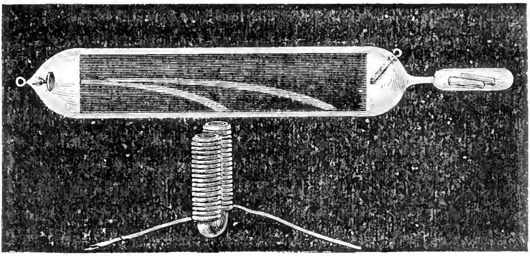
This action of the magnet is very curious, and if carefully followed up will elucidate other properties of radiant matter. Here

Fig. 14.



(Fig. 15) is an exactly similar tube, but having at one end a small potash tube, which if heated will slightly injure the vacuum. I turn on the induction-current, and you see the ray of radiant matter tracing its trajectory in a curved line along the screen, under the influence of the horseshoe magnet beneath. Observe the shape of the curve. The molecules shot from the negative pole may be likened to

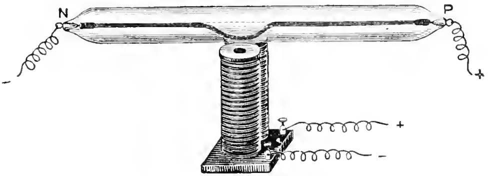
Fig. 15.



a discharge of iron bullets from a mitrailleuse, and the magnet beneath will represent the earth curving the trajectory of the shot by gravitation. Here on this luminous screen you see the curved trajectory of the shot accurately traced. Now suppose the deflecting force to remain constant, the curve traced by the projectile varies with the velocity. If I put more powder in the gun, the velocity will be greater and the trajectory flatter; and if I interpose a denser resisting medium between the gun and the target, I diminish the velocity of the shot, and thereby cause it to move in a greater curve and come to the ground sooner. I can not well increase before you the velocity of my stream of radiant molecules by putting more powder in my battery, but I will try and make them suffer greater resistance in their flight from one end of the tube to the other. I heat the caustic potash with a spirit-lamp and so throw in a trace more gas. Instantly the stream of radiant matter responds. Its velocity is impeded, the magnetism has longer time on which to act on the individual molecules, the trajectory gets more and more curved, until, instead of shooting nearly to the end of the tube, my molecular bullets fall to the bottom before they have got more than half way.

It is of great interest to ascertain whether the law governing the magnetic deflection of the trajectory of radiant matter is the same as has been found to hold good at a lower vacuum. The experiments I have just shown you were with a very high vacuum. Here is a tube with a low vacuum (Fig. 16). When I turn on the induction-spark, it

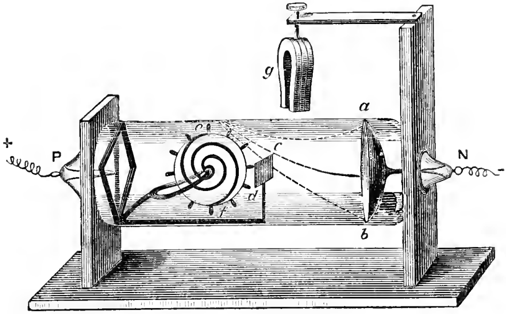
FIG 16



passes as a narrow line of violet light joining the two poles. Underneath I have a powerful electro-magnet. I make contact with the magnet, and the line of light dips in the center toward the magnet. I reverse the poles, and the line is driven up to the top of the tube. Notice the difference between the two phenomena. Here the action is temporary. The dip takes place under the magnetic influence; the line of discharge then rises and pursues its path to the positive pole. In the high exhaustion, however, after the stream of radiant matter had dipped to the magnet it did not recover itself, but continued its path in the altered direction.

By means of this little wheel, skillfully constructed by Mr. Gimingham, I am able to show the magnetic deflection in the electric lantern. The apparatus is shown in this diagram (Fig. 17). The negative pole (*a*, *b*) is in the form of a very shallow cup. In front of the cup is a mica screen (*c*, *d*), wide enough to intercept the radiant matter coming from the negative pole. Behind this screen is a mica wheel (*e*, *f*) with a series of vanes, making a sort of paddle-wheel. So arranged, the molecular rays from the pole *a b* will be cut off from the wheel, and will not produce any movement. I now put a magnet, *g*, over the tube, so as to deflect the stream over or under the obstacle *c d*, and the result will be rapid motion in one or the other direction, according to the way the magnet is turned. I throw the image of the apparatus on the screen. The spiral lines painted on the wheel show which way it turns. I arrange the magnet to draw the molecular stream so as to beat against the upper vanes, and the wheel revolves rapidly as if it were an overshot water-wheel. I turn the magnet so as to drive the radiant matter underneath; the wheel slackens speed, stops, and then

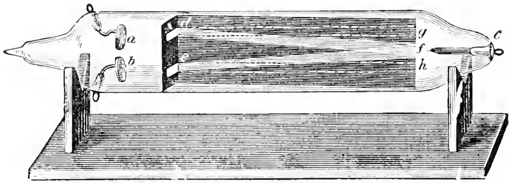
Fig. 17.



begins to rotate the other way, like an undershot water-wheel. This can be repeated as often as I reverse the position of the magnet.

I have mentioned that the molecules of the radiant matter discharged from the negative pole are negatively electrified. It is probable that their velocity is owing to the mutual repulsion between the similarly electrified pole and the molecules. In less high vacua, such as you saw a few minutes ago (Fig. 16), the discharge passes from one pole to another, carrying an electric current, as if it were a flexible wire. Now it is of great interest to ascertain if the stream of radiant matter from the negative pole also carries a current. Here (Fig. 18)

Fig. 18.



is an apparatus which will decide the question at once. The tube contains two negative terminals (*a*, *b*) close together at one end, and one positive terminal (*c*) at the other. This enables me to send two streams of radiant matter side by side along the phosphorescent screen, or, by disconnecting one negative pole, only one stream.

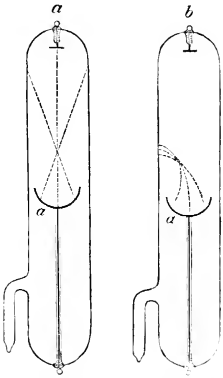
If the streams of radiant matter carry an electric current, they will act like two parallel conducting wires and attract one another ; but if they are simply built up of negatively electrified molecules, they will repel each other.

I will first connect the upper negative pole (*a*) with the coil, and you see the ray shooting along the line *d, f.* I now bring the lower negative pole (*b*) into play, and another line (*e, h*) darts along the screen. But notice the way the first line behaves : it jumps up from its first position, *d f*, to *d g*, showing that it is repelled, and if time permitted I could show you that the lower ray is also deflected from its normal direction : therefore the two parallel streams of radiant matter exert mutual repulsion, acting not like current carriers, but merely as similarly electrified bodies.

Radiant Matter produces Heat when its Motion is arrested.—During these experiments another property of radiant matter has made itself evident, although I have not yet drawn attention to it. The glass gets very warm where the green phosphorescence is strongest. The molecular focus on the tube, which we saw earlier in the evening (Fig. 8), is intensely hot, and I have prepared an apparatus by which this heat at the focus can be rendered apparent to all present.

I have here a small tube (Fig. 19, *a*) with a cup-shaped negative pole. This cup projects the rays to a focus in the middle of the tube. At the side of the tube is a small electro-magnet, which I can set in action by touching a key, and the focus is then drawn to the side of the glass tube (Fig. 19, *b*.) To show the first action of the heat, I have coated the tube with wax. I will put the apparatus in front of the electric lantern (Fig. 20, *d*), and throw a magnified image of the tube on the screen. The coil is now at work, and the focus of molecular rays is projected along the tube. I turn the magnetism on, and draw the focus to the side of the glass. The first thing you see is a small circular patch melted in the coating of wax. The glass soon begins to disintegrate, and cracks are shooting starwise from the center of heat. The glass is softening. Now the atmospheric pressure forces it in, and now it melts. A hole (*e*) is perforated in the middle, the air rushes in, and the experiment is at an end.

Fig. 19.



I can render this focal heat more evident if I allow it to play on a piece of metal. This bulb (Fig. 21) is furnished with a negative pole in the form of a cup (*a*). The rays will therefore be projected to a focus on a piece of iridio platinum (*b*) supported in the center of the bulb.

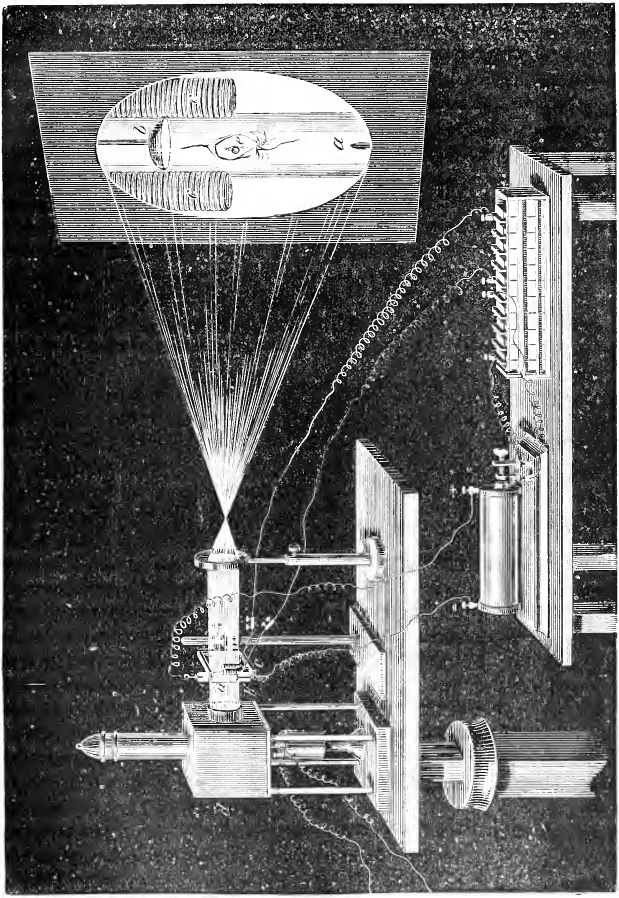
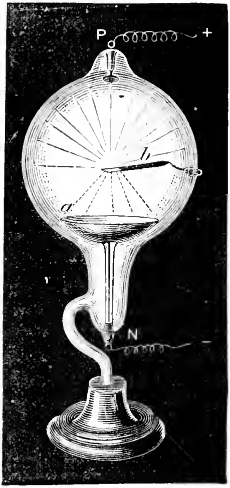


Fig. 20.

I first turn on the induction-coil slightly, so as not to bring out its full power. The focus is now playing on the metal, raising it to a white-heat. I bring a small magnet near, and you see I can deflect the focus of heat just as I did the luminous focus in the other tube. By shifting the magnet I can drive the focus up and down or draw it completely away from the metal and leave it non-luminous. I withdraw the magnet, and let the molecules have full play again;

the metal is now white-hot. I increase the intensity of the spark. The iridio-platinum glows with almost insupportable brilliancy, and at last melts.

Fig. 21.



The Chemistry of Radiant Matter.—As might be expected, the chemical distinctions between one kind of radiant matter and another at these high exhaustions are difficult to recognize. The physical properties I have been elucidating seem to be common to all matter at this low density. Whether the gas originally under experiment be hydrogen, carbonic acid, or atmospheric air, the phenomena of phosphorescence, shadows, magnetic deflection, etc., are identical, only they commence at different pressures. Other facts, however, show that at this low density the molecules retain their chemical characteristics. Thus by introducing into the tubes appropriate absorbents of residual gas, I can see that chemical attraction goes on long after the attenuation has reached the best stage for showing the phenomena now under illustration, and I am able by this means to carry the exhaustion to much higher degrees than I can get by mere pumping. Working with aqueous vapor, I can use phosphoric anhydride as an absorbent; with carbonic acid, potash; with hydrogen, palladium; and with oxygen, carbon, and then potash. The highest vacuum I have yet succeeded in obtaining has been the $\frac{1}{20,000,000}$ of an atmosphere, a degree which may be better understood if I say that it corresponds to about the hundredth of an inch in a barometric column three miles high.

It may be objected that it is hardly consistent to attach primary importance to the presence of *matter*, when I have taken extraordinary pains to remove as much matter as possible from these bulbs and these tubes, and have succeeded so far as to leave only about the one millionth of an atmosphere in them. At its ordinary pressure the atmosphere is not very dense, and its recognition as a constituent of the world of matter is quite a modern notion. It would seem that, when divided by a million, so little matter will necessarily be left that we may justifiably neglect the trifling residue, and apply the term *vacuum* to space from which the air has been so nearly removed. To do so, however, would be a great error, attributable to our limited faculties being unable to grasp high numbers. It is generally taken for granted that when a number is divided by a million the quotient must necessarily be small, whereas it may happen that the original number is so large that its division by a million seems to make little impression on it. According to the best authorities, a bulb of the size of the one before you (13·5 centimetres in diameter) contains more than 1,000000,-000000,000000,000000 (a quadrillion) molecules. Now, when exhausted to a millionth of an atmosphere we shall still have a trillion molecules left in the bulb—a number quite sufficient to justify me in speaking of the residue as *matter*.

To suggest some idea of this vast number, I take the exhausted bulb, and perforate it by a spark from the induction-coil. The spark produces a hole of microscopical fineness, yet sufficient to allow molecules to penetrate and to destroy the vacuum. The inrush of air impinges against the vanes and sets them rotating after the manner of a windmill. Let us suppose the molecules to be of such a size that, at every second of time, a hundred million could enter. How long, think you, would it take for this small vessel to get full of air? An hour? A day? A year? A century? Nay, almost an eternity!—a time so enormous that imagination itself can not grasp the reality. Supposing this exhausted glass bulb, indued with indestructibility, had been pierced at the birth of the solar system; supposing it to have been present when the earth was without form and void; supposing it to have borne witness to all the stupendous changes evolved during the full cycles of geologic time, to have seen the first living creature appear, and the last man disappear; supposing it to survive until the fulfillment of the mathematicians' prediction that the sun, the source of energy, four million centuries from its formation will ultimately become a burned-out cinder; * supposing all this—at the rate of filling I have just described, one hundred million molecules a second—this little bulb even then would scarcely have admitted its full quadrillion of molecules. †

But what will you say if I tell you that all these molecules, this quadrillion of molecules, will enter through the microscopic hole be-

* The possible duration of the sun from formation to extinction has been variously estimated by different authorities at from eighteen million years to four hundred million years. For the purpose of this illustration I have taken the highest estimate.

† According to Mr. Johnstone Stoney ("Philosophical Magazine," vol. xxxvi., p. 141), 1 c. c. of air contains about 1000,000000,000000,000000 molecules. Therefore, a bulk 13·5 centims. diameter contains $13{\cdot}5^3 \times 0{\cdot}5236 \times 1000,000000,000000,000000$ or 1,288252,350000,000000,000000 molecules of air at the ordinary pressure. Therefore the bulk, when exhausted to the millionth of an atmosphere, contains 1,288252,350000,-000000 molecules, leaving 1,288251,061747,650000,000000 molecules to enter through the perforation. At the rate of 100,000000 molecules a second, the time required for them all to enter will be—

12882,510617,476500 seconds, or
214,708510,291275 minutes, or
3,578475,171521 hours, or
149103,132147 days, or
408,501731 years.

fore you leave this room? The hole being unaltered in size, the number of molecules undiminished, this apparent paradox can only be explained by again supposing the size of the molecules to be diminished almost infinitely—so that, instead of entering at the rate of one hundred millions every second, they troop in at a rate of something like three hundred trillions a second! I have done the sum, but figures when they mount so high cease to have any meaning, and such calculations are as futile as trying to count the drops in the ocean.

In studying this fourth state of matter we seem, at length, to have within our grasp and obedient to our control the little indivisible particles which, with good warrant, are supposed to constitute the physical basis of the universe. We have seen that, in some of its properties, radiant matter is as material as this table, while in other properties it almost assumes the character of radiant energy. We have actually touched the border-land where matter and force seem to merge into one another, the shadowy realm between known and unknown, which for me has always had peculiar temptations. I venture to think that the greatest scientific problems of the future will find their solution in this border-land, and even beyond; here, it seems to me, lie ultimate realities, subtile, far-reaching, wonderful.

"Yet all these were, when no man did them know,
Yet have from wisest ages hidden beene;
And later times thinges more unknowne shall show.
Why then should witlesse man so much misweene,
That nothing is, but that which he hath seene?"

THE GENESIS OF SEX.*

By Professor JOSEPH LE CONTE.

THE subject on which I address you to-day is one which is still veiled in much obscurity—so much so, indeed, that it is barely alluded to by evolutionists, is not touched upon by physiologists, and is regarded by the popular mind, even the intelligent popular mind, as wholly beyond the possible ken of human science.

1. Defining the Subject.—In regard to the origin of sex there are two distinct yet closely-related questions: 1. The origin of sex in the history of the individual; 2. The origin of sex in the history of the organic kingdom. The one question is, "What are the conditions which determine the appearance of the one or the other sex in the de-

* In order to explain the forms of expression in some parts of this article, it is necessary to state that it was delivered in 1877 as a lecture to the class in Comparative Physiology in the University of California, and again in 1878 to the class in Physiology of the medical department of the same.

velopment of the embryo?" The other question is, "What is the process and what are the steps by which sex was developed and then gradually differentiated in the evolution of the organic kingdom?" The one is the genesis of sex in ontogeny; the other the genesis of sex in phylogeny. It is this latter question which I wish to bring before you to-day.

The two questions, however, though distinct, are yet closely related. The ontogeny is a rapid recapitulation of the main points of the phylogeny. As in the former, sex was developed out of a primitive sexless condition of the embryo, so in the latter the sexed condition so universal now among mature organisms was evolved out of a primitive sexless condition of the organic kingdom. In the ontogeny some of the conditions which determine sex have been determined and others surmised. In some animals, as, for example, in some insects and crustaceans, the fact of fertilization or non-fertilization determines with certainty the sex, as proved by the well-known observations of Siebold and others on parthenogenesis. In others it is probably the degree of maturity of the ovule at the moment of fertilization that determines it, as shown by the experiments of Cornaz under the direction of Thury.* In still others, as, for example, in butterflies, it seems to be the kind and degree of nutrition of the larvæ, as shown by the observations of Mrs. Treat.† In still others it may be the prepotency of the one parent or the other, or still other causes wholly unknown. In any case, however, the subject lies fairly within the domain of science; the conditions will eventually be discovered, and, being known, will be artificially arranged so as to determine the one sex or the other with certainty.

But this is not the question which now concerns us, for we have already discussed this in a previous lecture. We wish in this lecture to show that, in the history of the *organic kingdom* also, sex has been gradually evolved out of a primitive sexless condition, and if possible to catch some glimpses of the main steps of the process. The most important steps are indeed very obscure; but this is only because these are among the very earliest steps of evolution.

2. THE GENERAL LAW UNDER WHICH THE PROCESS FALLS.—Now, the law under which I wish to bring the process of evolution of sex is that most universal of all the laws of evolution, viz., the *law of differentiation*. We have already explained to you and illustrated in many ways how, from an almost unorganized condition, in which every part is like every other part, and each part performs in an imperfect manner *all* the functions necessary to life—how, I say, from this primitive generalized condition, the several organs were gradually differentiated, the several functions separated and localized, and thus the complex work of the body pareeled out by division of labor, until in the

* "Bibliothèque Universelle," September, 1863.

† "American Naturalist," 1873; "Popular Science Monthly," June, 1873.

highest organisms each part or organ has but one function to perform, and therefore does it thoroughly. You will observe that the final cause, the end to be attained, the *raison d'être*, in all this process is *better work*, a *better result*. Now, my object will be to bring the origin of sex under this general law—to show some of the steps, and that each step was attended with *better results*.

3. THE KINDS AND GRADES OF REPRODUCTION.—You already know that there are two fundamentally distinct kinds of reproduction, viz., *sexual* and *non-sexual*—so distinct, indeed, that there seems to be no possible connection between them. But remember that not only are our distinctions in science far more trenchant than they are in nature, but also that the distinctions in nature *now* are far more trenchant than they were in early geological times. It is the peculiarity of modern science, under the guidance of the doctrine of evolution, that it loves to dwell upon the gradations rather than upon the distinctions —it seeks for the missing links which make the chain of nature continuous. Now, there are several grades of sexual as well as of non-sexual reproduction; and through these grades they closely approximate each other. For example: sexual reproduction consists essentially in the union of *two* different cells, the *germ-cell* and the *sperm-cell*, to form *one* cell, the *ovum*. It is in the most literal sense *a union of diverse twain to form one flesh*. These two cells may be called the *sexual elements*. This is all that is absolutely necessary to the idea of sexual reproduction, *even though the two elements may be formed by the same organ*. But, further, the two elements are usually elaborated by two distinct organs, viz., the *ovary* and the *spermary*. These are the *essential sexual organs*. When these two organs are found in the same individual, the condition is called *bisexuality*, or hermaphroditism. Further, in the higher animals these two organs exist in different individuals. This condition is called *unisexuality*. Thus there are several grades of sexuality. The sexual elements only may be separated, or in addition the sexual organs may be separated, or in addition there may be distinct sexual individuals. Any mode of reproduction not answering to this description is non-sexual. But non-sexual reproduction also is of different grades. The lowest is *fission*. A cell or a community of cells grows and divides itself into two. Each half, again, grows and divides, and so on *ad infinitum*. Next above this is *budding*. A spot on the external surface of an organism grows more rapidly than contiguous spots, and forms a tubercle which grows into a bud, assumes the form and structure of the parent, and finally separates. In the next grade the budding is *internal*, from a special organ simulating an ovary, though not a true ovary, as in aphides. Finally, in parthenogenesis we have a perfect ovary forming true ova and perfect embryo without fertilization or coöperation of the sperm-cell.

Now, my object, more specifically stated, is to show—1, that the highest form, viz., unisexuality, was developed out of bisexuality or hermaphroditism; 2, that bisexual reproduction was developed out of non-sexual reproduction; and, 3, that non-sexual reproduction is but an unessential modification of the ordinary process of growth.

4. Facts which furnish a Key to the Process of Derivation.—There are certain facts which throw light on each of these steps, but, as might be expected, the light is far clearer on the higher steps, because these were also the last taken.

(*a.*) *Facts which bear on the Last Step, viz., the Derivation of Unisexuality from Bisexuality.*—These facts are taken from both the vegetable and the animal kingdom, but especially the former. They are comprehended under the general term "*cross-fertilization of bisexuals.*"

Plants.—It is a familiar fact that most plants are bisexual, i. e., have both ovary and spermary (anther-cell), in the same individual plant and in the same flower; and that nearly all such cases are capable of self-fertilization. But Mr. Darwin has shown that, although capable of self-fertilization, yet cross-fertilization—i. e., the fertilization of the ovules of one flower, or, still better, of the flowers of one plant by the pollen of another—produces more seeds, larger seeds, and stronger seedlings; in other words, produces *better results.* Now, it is a law which necessarily results from the principle of the survival of the fittest that Nature ever strives to secure better results. Therefore, she immediately sets to work to contrive methods of *insuring cross-fertilization* and *preventing self-fertilization.* The cross-fertilization is insured—1, by *winds*, aided by the lightness of the pollen; and, 2, by insects which carry the pollen from flower to flower. The beauty, the fragrance, and the honey of flowers are undoubtedly intended primarily to attract insects, and thus to insure cross-fertilization. But this alone is not sufficient. It is necessary also to prevent self-fertilization. This is done sometimes, as in orchids, by sticking together the pollen in masses by means of a gummy substance, so that it can not fly, and placing these masses entirely beyond the reach of the stigma, and sometimes by the maturation of the ovules and of the pollen at entirely different periods. In these cases the plant is wholly dependent upon insects for their fertilization, and we accordingly often find the most curious and ingenious contrivances in the structure of the flower to make sure that there be no failure in this respect. In other cases self-fertilization is still more effectually prevented by a separation of the sexes in different flowers (*Monœcia*), or in different plant individuals (*Diœcia*)—of course, winds and insects being still the carriers between the two sexes. This separation of the sexes was undoubtedly a gradual process. In bisexual plants, habitually cross-fertilized by winds or by insects, the one organ or the other became aborted until first only rudiments remained, and finally even these are lost and unisexuality is complete. These stages are sometimes detectable.

Animals.—In animals the process is probably similar. Many animals, such as oysters, polyps, etc., are bisexual and self-fertilizing. But even in these, cross-fertilization must be very common, if not the rule. These animals usually live together in great numbers; the sperm-particles are extremely light and abundant. These are therefore carried by waves and currents, so that the waters are full of them, and a promiscuous cross-fertilization is unavoidable. In fact, there can be no doubt that it is in order to insure this cross-fertilization that the sperm-particles are so light and abundant; and the final cause of this, again, is that cross-fertilization produces better results than self-fertilization. But if so, then Nature will take steps not only to insure cross-fertilization, but to prevent self-fertilization. This in animals as in plants can only be done in two ways, viz., either by so placing the two organs that self-fertilization is impossible, or else by separating them in different individuals. A curious example of the former method is found in snails. These animals are bisexuals—i. e., have both ovary and spermary perfect, but these are so placed that self-fertilization is impossible. They, therefore, *mutually cross-fertilize.* The latter method, of course, produces unisexuality, so universal in higher animals; but the process was probably the abortion, in habitually cross-fertilizing bisexuals, of one organ or the other in different individuals until unisexuality is established.

If, then, we compare plants and animals, we find the steps similar in the two kingdoms. Bisexual animals living together in numbers, and cross-fertilized by waves and currents, correspond to anemophilous flowers cross-fertilized by winds. Mutually fertilizing bisexuals like snails correspond to orchidaceous plants, except that the cross which is voluntary in the former is effected by insects in the latter. Finally, unisexuals in animals correspond to *Diæcia* in plants. In both kingdoms unisexuality is derived from bisexuality *—in both because thus self-fertilization is prevented and cross-fertilization secured; and this, again, because thus a better result is secured in the offspring.

But the question has probably dwelt in your minds, "Why is it that cross-fertilization produces better results, i. e., stronger progeny, than self-fertilization?" There are probably two reasons: 1. The elaboration of both ovules and sperm in the same individual is *wasteful of vital energy.* The concentration of vital energy on one reproductive element secures that one product in a higher degree of perfection. Thus better sperm and better ovules combine to produce better ova and a stronger embryo. This is in accordance with the effect of differentiation of functions and organs of all kinds. 2. Again, in all cross-fertilization different individual characteristics are inherited by

* This must be taken as a general statement only. It is probable that in many cases the opposite or retrograde change occurred, and that the difficulties in the way of cross-fertilization compelled a return to self-fertilizing bisexuality. Such retrograde changes are common in evolution.

the common offspring. Now, among the many characteristics thus inherited from both sides in the offspring, there is a sort of struggle for life and a survival of only the fittest and strongest, and thus the offspring improves by the cross. Now, such cross is most completely secured by the separation of the sexes in different individuals—i. e., by unisexuality.

(*b.*) *Facts which bear on the next Preceding Step, viz., the Derivation of Bisexuality from Asexuality.*—This is doubtless the most obscure step; yet I believe some light is visible. Here is the greatest gap in the process; yet this gap may be largely filled.

Remember, then, that there is a striking correspondence between the embryonic or ontogenic series and the evolution or phylogenic series—that the former is a rapid recapitulation, as it were by memory, of the main points of the latter. The embryo repeats by a kind of organic memory the main point of its descent from primordial protoplasm. The lesser points, and especially the earliest points, often indeed drop out of memory, but usually the main points remain. Now, in all the higher animals, ontogeny is a *continuous* change without break, and completed in *one generation.* In many lower animals, however, there are *apparent* pauses, and sudden great changes in this process of ontogenic development. These are called metamorphoses. In insects, for example, there are two active conditions, the larva and the perfect insect, and a sort of second passive egg-stage between—the pupa. Here we have a semblance of, but not really, two generations. Of course, only the perfect insect reproduces. But in many still lower animals we find the metamorphoses occupying two or even more distinct generations. It follows, of course, that in these animals (contrary to what occurs in all higher animals) reproduction takes place both in the larval condition and in the perfect or mature condition. Now, the mode of reproduction in these two conditions is of wholly different kinds, the former being non-sexual and the latter sexual. A single example will suffice: The common medusæ or jelly-fishes, as you know, are unisexual—i. e., male and female. The fertilized females produce eggs which grow, not into medusæ, but into polyp-like animals which are the larval form. These polyps produce buds which open into flower-like bells, then separate and swim away as male and female medusæ, which again produce eggs that spring up as polyp-like larvæ, etc. Here ontogenesis requires two generations to complete itself. In ontogenesis when both kinds of reproduction occur, the non-sexual (gemmation) precedes the sexual (ovulation). This fact strongly suggests, in fact renders almost certain, that the same is true in phylogenesis, or at least in the phylogenesis of this class.

But again: Aphids (plant-lice) also reproduce in the larval condition, and only reach maturity after many successive generations, sometimes as many as nine or ten. In spring these insects are hatched from eggs in a larval wingless condition. From an internal organ analogous to an ovary, but not a true ovary, these larvæ end another generation of larvæ like themselves, which in their turn, by internal budding, form a third generation, and so on until autumn, when the last generation develop into perfect winged insects, male and female. These last coöperate to produce eggs which hatch next spring, to commence another cycle of changes.

Here, then, we observe as before the lower form of reproduction in the larva, and the higher in the perfect insect. Here, again, we have non-sexual mode preceding the sexual mode in ontogenesis, suggesting a similar succession in phylogenesis. But in addition we observe here that the form of non-sexual reproduction very closely simulates sexual reproduction; for the budding is from an internal organ set apart for the purpose and very closely resembling a true ovary.

The next step in the chain of approximation is found in *parthenogenesis* or virgin generation. This consists in the formation, in a perfect female capable of sexual generation, of ovules which develop into embryos *without* the coöperation of the male element. In bees and wasps the ovules are sometimes fertilized and sometimes unfertilized. The fertilized eggs always produce *females*, the unfertilized always males. In this case the analogy to non-sexual reproduction is not close; because the female is, of course, the sex absolutely necessary to carry on the succession of generations, and it is this sex which it requires fertilization to produce. But in other cases, for example, in certain moths and in some phyllopod crustaceans, according to Siebold, the unfertilized eggs produce females and the fertilized males. In such cases, it is evident, a succession of females may be formed without the coöperation of the male; and thus we have continuous generation which is completely *intermediate* between sexual and non-sexual. It is sexual in that an embryo is developed from an ovule formed in a perfect ovary, it is non-sexual in that the coöperation of the male element is unnecessary even for an indefinite succession of generations.

On the other hand, the case of moths and phyllopod crustaceans approaches equally the case of aphids already mentioned—so much so, indeed, that the larval reproduction of these latter have often been classed under parthenogenesis. The difference is this: true parthenogenesis takes place in perfect females, capable of sexual union and of fertilization, possessing perfect ovaries and producing true ovules which develop into embryos without fertilization. The larval aphid, on the contrary, is not a perfect female, is not capable of sexual union nor of fertilization; its ovary-like organ is not a true ovary, does not produce true ovules which develop into embryos, but forms an embryo at once within, which then is born in an active state. Still the resemblance to parthenogenesis is undoubted, and together they almost wholly fill up the gap between the sexual and non-sexual modes of reproduction.

There is still another fact which must be brought forward to fill this gap. True sexual reproduction, as we have seen, consists essentially in the union or *conjugation* of two *diverse* cells (sperm and germ cell) to produce one cell (ovum). Now, in the lowest forms of sexual reproduction, among unicelled organisms, the *conjugating cells are not perceptibly different*; so that the element of diversity in the conjugating cells may be eliminated from the essential conditions of this mode. In parthenogenetic reproduction of female offspring, as in the case of moths and phyllopods, we have the other element, i. e., the necessity of *two* cells, eliminated; so that there remains nothing which is absolutely essential.

(*c*.) *Facts which bear on the First Step, viz., Derivation of Non-Sexual Modes from Ordinary Processes of Growth.*—The transition between the lowest form of non-sexual reproduction, viz., fission, and ordinary growth, is so obvious that it is hardly necessary to insist on it. A single cell divides itself into two; each half grows, and again divides itself into two, and so on. Now, if the cells cohere, we call it growth; if they separate, we call it reproduction. Again: a *mass* of cells grows by continued cell-multiplication, as above. Finally, the increasing mass or community becomes too large to be managed well from one center; it therefore divides itself into two masses or communities, each of which continues to grow as before. It is plain that a slight difference only in the degree of cohesion determines whether the same process be called growth or reproduction.

Thus we have shown the easy gradation, and therefore the probable derivation, of the highest mode of sexual reproduction—the unisexual—from the ordinary processes of growth, through the different grades of asexual and bisexual reproduction. The derivation of different modes of sexual reproduction from each other will not, I think, be questioned. Still clearer is the fact that non-sexual reproduction is but a modification of the ordinary process of growth. The only place where there is any gap is between the *asexual* and the *sexual* modes. Throughout growth and non-sexual modes of reproduction we have everywhere only *cell-multiplication*—everywhere we have *division of one to form two:* in sexual reproduction, on the other hand, we have the contrary process, viz., *the union of two to form one.* Yet this gap is certainly partly filled by the larval reproduction of aphids, by those cases of parthenogenesis in which unfertilized ovules produce females, and those cases of true sexual generation in which the conjugating cells are similar.

5. Outline of Probable History of the Process.—The gradual evolution of the higher forms of sexual reproduction probably took several different roads. There is little doubt that in some cases sexual reproduction in its simplest form was reached at a very early period. It is probable, for example, that in very early times unicelled organisms multiplying usually by fission (asexual) from time to time conjugated (sexual). The simple form of sexual reproduction thus reached was afterward perfected. But it is also probable, nay, judging from the

transitional stages still in existence, almost certain, that in other cases sexuality was reached by a slower process and at a later period. It is this slower process which I now wish to trace in outline :

(*a.*) *Fission.*—In the lowest animals the individual cells which form their structure are almost wholly independent. The independent life of the cell is strong, the common life of the aggregate is feeble. By continued cell-multiplication, the aggregate, becoming too large to be held together by the common life, divides. Thus arises the lowest form of reproduction, viz., by fission. Many lower animals still practice this mode.

(*b.*) *Budding on Any Part.*—In the next step excess of growth occurs on any part indifferently, gives rise to a tubercle which grows into a bud, assumes the structure of the parent stem, and finally separates to become a new individual. This is higher than the last, because the original individual is not sacrificed, but only a part separated. Many larval medusæ and many polyps still practice this mode.

(*c.*) *Budding on a Special Part.*—In the last case the budding occurs in any part. In the next step a particular part is selected, and to it is assigned the function of forming buds which form new beings. Many larvæ of medusæ belong to this category ; for they bud only on the mouth-disk. This is a higher form than the last, inasmuch as the assignment of a function to a particular place, or localization of a function, is an invariable step in evolution, and always attended with better results.

(*d.*) *Special Budding Organ, internal.*—The next step was probably the relegation of the function of producing buds to an internal organ, as being far safer and more certain of success, which organ thus becomes by position and function strongly analogous to an ovary. This is the case in larval aphids. The reproductive organ of these larvæ has been regarded by *some* as an ovary, by others as an internal budding organ. It is certainly not a true ovary, but rather perhaps an organ uniting the yet undifferentiated functions of ovary and spermary, an organ producing cells having the properties of both germ-cells and sperm-cells, and therefore capable of directly forming an embryo by cell-multiplication.

(*e.*) *Differentiation of Sexual Elements.*—The interior reproductive organ last described next forms two kinds of cells which by conjugation produce the ovum ; the sexual *elements* are now differentiated, but not yet the sexual *organs*. It is not absolutely certain that this condition actually exists in any species now living ; but it is *probable* that it does. According to Kleinenberg,* the reproductive organ of the hydra produces both ovules and spermatozoids. In many mollusks and polyps the separation of the ovary and spermary is not yet made out. In some gasteropods the epithelial cells of the *oviduct* seem to become mother-cells, in which are produced *spermatozoids.* The sepa-

* "Annals and Magazine of Natural History," vol. ii., p. 351, 1878.

ration here is only partial. Preceding the condition represented by the hydra, and connecting with the last (*d*), we ought to find one in which two *similar* cells elaborated by the same organ unite or conjugate to commence the new life—a condition in which the sexual elements are *potentially* but *not visibly* differentiated. This condition is realized, as far as we yet know, only in the conjugation of unicelled organisms.

(*f.*) *Bisexuality.*—The next step is of course the complete differentiation not only of the sexual *elements*, but also of the sexual *organs*. This is bisexuality or hermaphroditism, very common, as is well known, among lower animals and almost universal among plants.

(*g.*) *Unisexuality.*—The last step is the separation of the sexes in different individuals. This of course effectually prevents self-fertilization in both animals and plants. But cross-fertilization must be insured. This, as already seen, is done by winds and insects in the case of plants, and by waves and currents in some lower animals. These agents do not, however, insure fertilization in higher animals. Therefore, in them there is added sex-appetite and all associated feelings for that purpose.

(*h.*) After the separation of the sexes has been a sufficiently long time accomplished, the evidence in the ontogeny of former conditions is gradually obliterated—the memory of them is lost.

6. Differentiation of the Two Sexual Individuals.—We have now reached complete unisexuality—i. e., the separation of the sexes into different individuals, but not yet the very best results. Unisexuality is better than the orchid and snail method of *mutual* fertilization, only because the latter method is incapable of further differentiation, and therefore of any further improvement of results. In cases of mutual fertilization the individuals are all alike, except these small individual differences, which occur even in self-fertilizing bisexuals. But as soon as the sexes are separated into different individuals, then there is room for indefinite differentiation of the two sexual individuals. Now, as we go up the animal scale we find that such differentiation has indeed taken place, and that progressively. The sexual differences—i. e., the difference between male and female individuals of the same species—become greater and greater as we rise in the scale. They are also greater, we believe, in the higher as compared with the lower races of man, and in the cultivated classes as compared with the uncultivated classes. From this sexual difference springs sexual attractiveness, and from this lowest root, it is not too much to say, springs much if not all our noblest altruistic nature. For, as our physiological functions are primarily divisible into two great groups, viz., the nutritive and the reproductive, the one including all that assemblage of functions which conserve the individual life, the other all that assemblage of functions which conserve the continuous life of the species, so all our psychical functions are also primarily divisible into two groups, the egoistic and

the altruistic—the one concerned only about the well-being of self, the other about the well-being of the race. These correspond each to each. Traced to its deepest physiological roots, the one in its last analysis is connected with the nutritive functions and the appetite for food, the other with the reproductive functions and the sexual appetite.

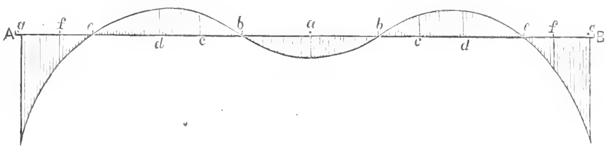
It seems to me not inappropriate to draw passing attention to the fact that that form of woman's rights which would assimilate as much as possible the two sexes is certainly in direct conflict with the law of evolution which we have been tracing. If founded in nature at all, we must seek for its justification in a higher law than that of animal evolution.

7. Crossing of Varieties.—Are there still further differentiations and still better results possible? Yes; by judicious crossing of varieties. Groups of individuals of both sexes, under the influence of differing environment, become different. This difference may be slight (slight varieties), or decided (strong varieties), or still more decided (races), or may become in time so great as to constitute distinct species. Now, it has been found that the indefinite interbreeding of individuals subject to identical conditions (close-breeding) produces weakness and degeneracy; and, on the contrary, the judicious crossing of slight varieties produces improved results. The reason is apparently this: Among all the qualities, good and bad, strong and weak, inherited from both sides by the offspring, there is a kind of struggle for life, and a survival of the best and the strongest qualities. It is probable that this improvement is more decided in the psychical than in the physical nature, and therefore is more conspicuous in man than in animals. Too close breeding—i. e., the interbreeding in isolated communities of individuals subject to identical conditions, and therefore with identical customs, habits, feelings, thoughts—tends to deteriorate the mind and character, even when the physique is unimpaired; tends to petrify the communal character and destroy that plasticity on which all progress depends.

Now, it is quite certain that *within certain limits* the improved results of crossing increase with the diversity of the crossing varieties. But mark, only within certain limits, beyond which they again decrease until deterioration is reached; and the deterioration increasing with the increasing divergence, when the crossing varieties reach a divergence represented by the term *species*, Nature practically forbids the ban. Thus, when species cross, there is either (*a*) no fertilization, and therefore no offspring; or (*b*), the offspring is an infertile hybrid, and therefore perishes in the next generation; or (*c*), if the offspring be fertile, the progeny is feeble, and perishes in the struggle for life in a few generations, or (*d*) is absorbed by crossing with the stronger parent species. If this were not so, species, in many cases at least, could not exist. Many species of oak or of pine grow in the same grove; the air is full of the pollen of many species; the conditions necessary for the crossing of different species must constantly occur, and yet the species remain distinct. The same is true of many hermaphrodite species of marine animals living in great numbers together; the water is full of the sperm of several species, and the conditions of cross-contact of sexual elements are constantly present, and yet species remain substantially distinct.

It is evident, therefore, that in close-breeding, and in the crossing of varieties of different degrees of divergence, there is, first, a less than average result, then an average, then better than an average, then this better result quickly reaches a maximum and again declines, crosses the line of average and becomes bad, and finally infinitely bad, or dies out. In the human species it is probable that the crossing of those varieties called national varieties, even strong national varieties, produces good results; but the crossing of varieties so divergent as those called primary races is probably bad—these approaching too nearly the nature of different species.

The general law of the effect of breeding may therefore be graphically represented by the following diagram, in which the absciss A B represents the level of average result, distance on this absciss from the middle point *a* represents the divergence of crossing varieties, and ordinates positive and negative represent the result of crossing, whether good or bad. Further, the middle point *a* represents no divergence or identical individuals, the distance *b b* individual differences, *c c* divergence constituting slight varieties, *d d* strong varieties, *f f* races, and *g g* species. By inspection of the figure it is seen that close-breeding (*a*) produces negative ordinates or bad results, then going from this



point the curve crosses the line of average at *b b*, then the ordinates become positive and reach maximum at *d d*, or *strong varieties*, then again crosses the line of average and becomes negative at *f f*, indicating the bad effect of crossing *races*, and finally becomes infinitely negative before it reaches *g g*, showing the practical infertility of crossing different species under natural conditions.

If I am right in this view, then the mixing of primary races is bad, and such mixed races, as weaker varieties in the struggle for life, must perish. There is one possibility which may save these races. Admitting the fact of deterioration as an immediate result of universal crossing of existing races, it is possible that by judicious crossing again of the slight varieties which must eventually arise in the mixed race, this common, inferior result may again be raised to a higher level. Thus, if the present higher races could consent to sacrifice their present superior position for several, perhaps *many*, generations, it is conceivable that the human race may be again raised, and possibly to a still higher plane. From a lower plane but broader base, it may be possible to build up again to a higher point than any yet reached. Or, to put it differently : the effect of true breeding is doubtless excellent in one direction, and for the perfecting of one or a few qualities, but it tends also to specialize, and therefore to petrify, and thus to prevent indefinite progress. Mixing, on the other hand, it produces a more plastic nature or better clay, a more generalized and therefore a more progressive form—for the line of true progress has ever been through generalized forms. Therefore it *may be* that, after the best results of true breeding have been attained in the production of the best varieties in *several limited directions*, then the general mixing of these perfected varieties will produce a generalized human type capable of more universal progress in *all* directions.

OCEAN METEOROLOGY.

By Lieutenant T. A. LYONS, U. S. N.

II.

THE frequent examination of Maury's charts for the purpose of shortening tedious passages under sail, led to the idea of remodeling them for greater ease of consultation, and at the same time of adding the vast store of data accumulated since their publication.

The first conception of the new charts embraced only their salient features : from time to time, during the progress of the work, various details occurred and were added, so that to-day the undertaking may be said to be systematized, and it is this system which I shall describe.

The sources whence the information for the charts is derived, are two : log-books of ships of our own navy, and journals of merchant-vessels.

On board every vessel of the United States Navy it is obligatory to keep an official daily record, called the log-book. The first part contains full and explicit directions for keeping it ; lists of the officers and men composing the ship's company ; plans and sections of the ship ; a description of the armament, boats, and small-arms ; a table of deviations of the compasses ; and a description of the meteorological instruments used, their location, and comparisons with standards. Following this matter are blank pages, suitably ruled, for a six months' record, two pages for each day; the left-hand page is chiefly for meteorological observations—the right, for miscellaneous events.

At the end of *every hour*, both day and night, and in port as well as at sea, the following items are observed by the midshipman of the watch, and recorded in their respective columns: the speed of the ship; direction and force of the wind; leeway; height of mercurial barometer and its attached thermometer; temperature of the air and of evaporation (dry-bulb and wet-bulb, both in a lattice-work case); temperature of the sea at the surface; weather by symbols; forms of clouds; portion of sky clear; condition of the sea; and the sail the ship is under. At the end of *every four hours*, the lieutenant in charge of the deck enters on the right-hand page such particulars of the weather as could not be described in the columns, together with whatever events occurred during his watch. *Every day* at sea, the navigator enters on the left-hand page the distance run since the preceding noon; the latitude and longitude at noon, both by observation and by account; the current (if any) experienced during the day; and the variation of the magnetic needle with the position in which it was determined.

The watches or tours of duty on board a vessel of war are divided into four-hour periods, each watch being in charge of a lieutenant, assisted by a midshipman; the number of observers throughout the twenty-four hours will, therefore, vary with the number of watch-officers: generally there are four.

Each lieutenant is solely responsible for the correctness of the log during his watch; but, as different officers contribute to the record of a day, this lays the log-book open to both error and incongruity, if a general supervision were not exercised by some *one* person. Such is daily done by the navigator, who, after examination, certifies to its correctness, and then the commanding officer examines and approves it.

With accurate instruments, careful observers, and this system of scrutiny, there remains nothing to be desired in the way of a continuous, complete, and accurate record of the experience of a ship, whether cruising on the high-seas or at anchor in a landlocked harbor; and it is believed that more trustworthy observations are never taken at sea. Furthermore, they are made at such short intervals—every hour—and the atmospheric phenomena and corresponding instrumental changes are so closely contrasted side by side that no error, break, or flaw can enter, without easy detection.

I have been thus explicit regarding the log-books, in order that the accuracy of the charts which are based upon them may be fully appreciated.

As regards the data furnished by merchant-vessels, in 1878 a very complete meteorological journal was prepared at the Hydrographic Office for the use of ship-masters, and is issued to them free of charge either from the office directly, or from one of its agents in the principal commercial ports of the world. It is essentially like the log-book of the navy, and is for observations at sea only. When full, it is to be transmitted to Washington at the expense of the office. A number of sailing charts and all the latest hydrographic information are supplied gratis as an inducement to keep the journal. Hundreds of them are already afloat on ships of various nationalities, and are being filled with valuable data regarding every sea known to commercial enterprise.

Before proceeding to describe the method of compilation, I shall dwell for a moment on one of the items of record in the log-book, viz., the ascertainment of the ship's speed. Besides probably being of interest to many who yearly cross the sea in quest of either pleasure or health, a knowledge of this will tend to elucidate another matter of which I shall speak hereafter—the determination of whatever currents are drifting a ship, it may be, into serious danger.

The ship's speed is found by "heaving the log." The principle involved is the same as if one were to fasten the end of a tape-line, which is coiled on a spool, to a post, and then, holding the spool in his hand, he walked from the post at a uniform pace, allowing the line to easily roll off, but not become slack. If at the end of one minute he had walked 300 feet, in an hour he would have walked (at the same rate) 18,000 feet, or about three nautical miles.

Now, no stationary point exists in the ocean from which to measure, but this desideratum is attained by means of a thin flat board, sector shape, of eight inches' radius, and with the rounded edge loaded with lead to keep it upright in the water. Short lines connect the three corners of this "log-chip," as the sector is called, with the "log-line"—one of them by means of a wooden plug which is gently forced into a hole in a piece of wood fastened to the log-line about two feet from the chip. After well soaking and stretching, the log-line is marked as follows: A length of it about 100 feet from the chip is allowed for "stray-line," and then the length of a "knot" (for the sand-glass that runs for 28 seconds) is determined by this proportion. As the number of seconds in an hour is to the number of feet in a nautical mile, so is the length (in time) of the sand-glass to the length (in feet) of a knot; or 3600 : 6086=28 : 47·33.

The limit of stray-line from the log-chip is marked by a piece of red bunting six inches long, and each length of 47·33 feet after that by a piece of fish-line with one, two, three, etc., knots in it, according to its number from the limit of stray-line. Each length of 47·33 feet (the "knot") is subdivided into five equal parts, and a small piece of white bunting two inches long is turned into the line at every two-tenth division thus formed.

"To heave the log" is performed thus: one person holds the sand-glass, another the reel on which the log-line just described is coiled, and a third throws the log-chip with the line attached over the ship's stern; the chip, floating upright, is kept stationary by the resistance of the water, while the vessel moves on, and the line runs out; the midshipman watches it until the limit of stray-line just passes the rail, when he sharply says "TURN"; the glass is quickly reversed, the sand begins to run into the lower compartment, and both time and space are reckoned from the word TURN. The "knots" reel off slowly or rapidly according to the ship's velocity, and, when the last grain of sand runs out, the line is instantly stopped. The number of knots and tenths run out denotes the speed at the moment of making the experiment, and, according to the conditions of wind, sea, and sail for the whole hour, the speed is deduced for the hour, and so entered in the columns.

To draw in the line, a quick, strong jerk on it frees the plug, when the chip floats horizontally, and can be hauled aboard with little resistance.

The "course steered," which is always a coördinate entry with the velocity, is obtained from a standard compass, whose every error is found and tabulated, to be applied when necessary. As the course and velocity are entered every hour in the log-book, we have thus a continuous record of each direction in which the ship headed, together with the distance she proceeded in that direction.

The courses and distances are the data by which, with the aid of a traverse-table, the ship's position may be found at any time—the position by "dead reckoning," or "account," as it is called. Independently of this, the position—"by observation"—is daily found by the navigator by altitudes of the sun, the moon, or the stars.

Suppose a ship to leave New York at noon of any day, and that her "run" is accurately kept until noon of the next day, when the latitude and longitude by account are found. The ship may not really be in this position: currents may have borne her along or athwart her course, yet we can not discover them; they act on log-chip and vessel alike: but let the position "*by observation*" be determined for the same instant that it is "*by account*," and we have at once a standard of comparison whereby the treacherous streams are made known. If none exist, the position by the two methods should agree within the small limit of error due to the unavoidable imperfection of both observers and instruments.

A third mode of ascertaining the ship's run is by the patent log—an instrument constantly towed astern at the end of a long line. It has a small propeller which the motion through the water causes to revolve. This revolution is communicated to a series of cogged wheels connected with hands that point to a circular scale—an arrangement not unlike a gas-meter. Every noon the log is hauled aboard, read, reset, and then thrown overboard, to record again the number of miles by which the ship nears her port. Being entirely independent of both dead reckoning and observation, it forms a kind of check on those two methods.

I will now enumerate some corroborating circumstances that must be considered in connection with the difference between the position by observation and that by account, ere this difference—its set and velocity—be tabulated as one of the permanent, ever-flowing currents of the ocean :

I. Temperature.—Of two contiguous bodies of water—one hot, the other cold—the latter, being specifically heavier, will displace the former, and hence a *permanent* current is established.

II. Evaporation.—Since no salts are taken up in the vapor, a body of salt water from which great evaporation takes place will be specifically heavier than an adjoining one that gives off less vapor, and so a *continuous* flow from the dense to the light fluid will be maintained.

III. Winds.—In a gale, the waves roll one after another in huge volumes toward the point to which the wind blows ; and the friction of the wind upon the water produces a *temporary* surface set to leeward.

IV. Difference of Barometric Pressure.—In gales of wind, it is common for the barometer to fall from, say, 30·20 to 29·70—half an inch—in less than a day, and while the ship is passing over a comparatively small extent of ocean. Take a very extreme case, merely for illustration. Suppose two contiguous square miles of ocean, the barometer standing 30·20 over one of them, and 29·70 over the other. This difference of half an inch in the barometer is equivalent to a difference of about one quarter of a pound pressure per square inch of surface, or 36 pounds per square foot. Taking 6,086 feet as the side of a square mile, it will contain 37,039,396 square feet ; each square foot sustains a *difference* of pressure of 36 pounds, so that there are in all 1,333,418,256 pounds *more* pressure on the square mile over which the barometer stands 30·20 than on the one over which it stands 29·70. It is evident that, in order to attain an equality of level, a very decided *temporary* set must take place from the former square mile toward the latter.

Instead of confining the case to the impossibly small area of two square miles, let us suppose a gradual fall of the barometer from one part of the ocean to the other—such a fall, in fact, over such an area as often comes within the experience of every naval officer—and it stands to reason that waves of the ocean, like those of the air, only smaller and more sluggish, are consequent upon every change of the barometer.

V. Rotation of the Earth.—From being at rest, suppose the earth to begin to revolve, as now, from west to east. On starting, the water of the ocean would, owing to its inertia, recede from the western shores of all the continents, and, as the earth continued to revolve, it would flow to the westward. For two reasons, however, it would be confined to equatorial regions: first, the centrifugal force there is greatest; and, second, the meridians converge as we near the poles.

This second reason will appear evident if we suppose a body of water of five degrees area and any depth to set out from the equator toward either pole. At each remove it would find the linear dimensions of a degree smaller. The depth remaining constant, its volume would be too great for an area of five degrees square in latitude 30°, still more so for one in latitude 60°, and so on. This constant crowding in extra-tropical zones would therefore constitute an opposing force sufficient to confine the flow of water to a zone where its volume would undergo little or no compression—that is, in the vicinity of the equator.

Arriving, then, at the eastern shores of the continents to the westward of those from which it started—at the North and South American shores, for instance, having started from Europe and Africa—and being banked up by constantly arriving volumes of water, it would be forced to the northward and to the southward along the coast-line of each continent; it would then flow to the eastward in high latitudes until reaching the western shores of the continents from which it started, where, owing to the divergence of the meridians toward the equator and the greater centrifugal force at that parallel, it would flow from the north and from the south along the shore-lines of the continents until reaching the intertropical zone, where it would again start westward on its circuit.

Imagine this system of circulation once set up, and nothing is more natural than that it should continue while the earth revolves; indeed, a glance at any current chart of the world will suffice to show the force of this reasoning.

It will now be seen how important a part the thermometer and hydrometer play in the discovery of oceanic currents: by the former a difference of temperature, and by the latter a difference of density, is quickly detected; and, if a decided difference of either kind is found, a *permanent* current may be fairly inferred. A consideration of the winds, whether an accidental gale, the constant trades, or the seasonal monsoon, may lead us to deduce intelligently whether a set that may have been experienced for days is a *temporary* surface-flow or a *permanent* current. So, also, keeping in view the range of the barometer for a few days—the locality and amount of its rise or fall—may assist in deciding whether a certain set be due to its extreme range or not. A consideration of the rotation of the earth is of assistance only in determining the general direction of the great ocean-currents.

A few other entries of the log-book require a passing notice. The *direction* of the wind is indicated by a vane in connection with a compass, and its *force* is *estimated* according to the following scale:

Force of wind, nautical scale.	Nautical designation.	Sail that a full-rigged ship may carry, close-hauled by the wind; also her probable speed.	Sail that a full-rigged ship may carry, wind on quarter; also her probable speed.	Force of wind in pounds per square foot.	Velocity of wind in miles per hour.
0	CALM.	All sail.	All sail.	0	0
1	LIGHT AIRS.	All plain sail and stay-sails; smooth sea; 0·5 to 1 knot per hour.	All plain sail and studding sails; smooth sea; 1 to 1·5 knots per hour.	0·004 to 0·019	1 to 2
2	LIGHT BREEZES.	All plain sail and stay-sails; smooth sea; about 2 knots.	All plain sail and studding-sails; smooth sea; 2 to 3·5 knots.	0·08	4
3	GENTLE BREEZES.	All plain sail and stay-sails; smooth sea; 3 to 4 knots.	All plain sail and studding-sails; smooth sea; 4 to 5 knots.	0·36	9
4	MODERATE BREEZES.	All plain sail and stay-sails; smooth sea; 5 to 6 knots.	All plain sail and studding-sails; smooth sea; 6 to 7 knots.	1·0	14
5	STIFF BREEZES.	Courses, top-sails; to'-gallant sails, and stay-sails; mod. sea; 6 to 7 kts.	All plain sail and studding-sails; moderate sea; 8 to 9 knots.	1·5	17
6	FRESH BREEZES.	Courses, single-reefed top-sails, to'gallant sails; moderate sea; 7 to 9 knots.	Courses, top-sails, to'-gallant sails, lower and topmast studding-sails; mod. sea; 10 to 12 kts.	2	20
7	VERY FRESH BREEZES.	Courses, double-reefed topsails, fore topmast stay-sail; moderate sea; *about* 7 knots.	Courses, single-reefed top-sails, to'gallant sails; moderate sea; 12 to 14 knots.	3	24
8	MODERATE GALE.	Single-reefed courses, treble-reefed fore and main top-sails, close-reefed, mizzen, fore top-mast stay-sail; rough sea; 4 to 5 knots.	Single-reefed courses, double-reefed fore and main top-sails, close-reefed mizzen; rough sea; about 10 knots.	5	30
9	STRONG GALE.	Close-reefed courses, close-reefed fore and main top-sails, storm stay-sail; rough sea.	Close-reefed courses, close-reefed fore and main top-sails, storm stay-sails; rough sea.	8	40
10	VERY STRONG GALE.	Close-reefed fore sail, close-reefed main top-sail, fore storm stay-sail; very rough sea.	Close-reefed fore-sail, close-reefed main top-sail, fore storm stay-sail; very rough sea.	23	67
11	VIOLENT GALE.	Storm-sails, or close-reefed main top-sail and fore storm stay-sail; very rough sea.	Close-reefed fore-sail, close-reefed main top-sail, fore storm stay-sail.	32	80
12	HURRICANE, TYPHOON, CYCLONE.	None; lying to; drifting bodily to leeward.	Scudding under bare poles.	50 and upward.	100 and upward.

The above sail and speed, corresponding to various forces of the wind, are but approximations to what really takes place according to particular circumstances, such as model of ship, course steered with reference to the wind, condition of the sea, etc.

The customary designations of the clouds are employed, and the portion of clear sky is denoted by figures—10 representing a wholly clear sky, 0 an entirely cloudy one, and intermediate numbers a sky partly clear and partly cloudy.

In the column descriptive of the weather, the following symbols are used, and by means of them, all the possible variations of weather that can occur in an hour, may be succinctly and accurately described:

b.—Clear blue sky.
c.—Cloudy weather.
d.—Drizzling or light rain.
f.—Fog, or foggy weather.
g.—Gloomy, or dark, stormy-looking weather.
h.—Hail.
l.—Lightning.
m.—Misty weather.
o.—Overcast.
p.—Passing showers of rain.
q.—Squally weather.
r.—Rainy weather, or continuous rain.
s.—Snow, snowy weather, or snow falling.
t.—Thunder.
u.—Ugly appearances, or threatening weather.
v.—Variable weather.
w.—Wet, or heavy dew.
z.—Hazy.

We now arrive at the method of compilation, and for this several blank forms are used which will be described as the necessity arises to speak of each kind.

First, however, every log-book and journal is closely examined for any errors it may contain, and, if such exist, they are scored with a red pencil, and hence do not enter into the compilation or charts.

Whatever judgment of the log-book this scrutiny warrants, is entered in it for guidance of the compiler.

The first blank to be used is *Form A*—a sheet 36 inches by 20. It is a projection according to Mercator of that part of the sphere between the 70th parallels of latitude north and south. Beginning with the equator and the meridian of Greenwich, parallels and meridians are drawn at every fifth degree, thus dividing the ocean, like a chess-board, into small squares. These are numbered consecutively from 1 to 1,667, so that, either by its number or its limits in latitude and longitude, the expanse of ocean covered by any square can be designated.

When a ship makes a passage under sail, she will cross certain of these squares on devious courses, and be in each square a short or a long period according as the winds and weather favor or oppose her. The particular square in each day can be ascertained by referring the noon position to Form A; and the hour of entering and of leaving it can be found by working the ship's run, by means of the courses and distances, backward or forward as necessary, from the noon position. Then, drawing heavy lines across the left-hand or meteorological page of the log-book at the hours of entry and of exit, it is evident that all the observations between these lines were taken in that square.

The limits of all the squares traversed are determined and marked in like manner, the number of each square is written between its bounding lines, and, when thus wholly prepared, the observations taken in each square during whatever length of time the ship was in it—whether one hour or several, provided it was continuous time in the same month—are compiled on one blank of *Form B*. This is a sheet of thick, durable paper, so ruled into columns with appropriate printed headings that each of the following-named items has a place for entry: the limits in latitude and longitude of the square, its number, and the number of hours the ship was in it; date of passing through the square, name of the ship, and the period covered by her log-book—all, that direct reference may be had at any time to the original sources. In a series of columns the thirty-two points of the compass are printed in regular order; blank spaces are provided on the right and left of each point—those on the left for the number expressing the wind's duration from that point, and those on the right for the figure denoting its mean force for the period of that duration. To compile the direction of the wind, the number of hours it was from the same point, whether consecutively or at different intervals, are counted, and the sum total is entered on the left opposite the point; for the force, the mean of the several hourly forces corresponding to the period of direction just mentioned is found and entered on the right of the point. Similarly for each point from which the wind blew while the ship was in the square.

As the entries regarding the wind in the log-book are hourly estimates of both its direction and force, for the hour—an interval that permits little variability in either quantity—accuracy to this degree is insured in both the compilation and charts. There is no averaging the force or direction for longer periods than an hour, and, as far as I am aware, this is the only system pursued by any nation wherein these items are compiled with such detail.

When calms or light, variable airs occur, the number of hours of each is counted, and the sum entered in its proper place. When a gale—that is, wind of a force of 8 and upward—happens, the number of hours it blew from any of the eight principal points of the compass (supposing it to have varied in direction), together with the force during each period, are duly tabulated.

The total number of hours of fog, of rain (including snow and mist), and of squalls (heavy, moderate, and light); the state of the weather by symbols; quantity of clear sky; and variation of the magnetic needle, with the location in which it was observed, are all entered in their respective places.

The mean of the mercurial barometer, attached thermometer, dry-bulb, wet-bulb, and temperature of the sea-water at the surface—that is, the mean of all the hourly observations of each of these quantities while in the square—is found and entered. Beside each is placed its daily range, by which is to be understood the mean of the differences between the daily maxima and minima for the number of days the ship was in the square.

Throughout a wide zone on both sides of the equator, the barometer has a remarkably regular oscillation, attaining two maxima and two minima every day. In order to discover the extent of this phenomenon, the hours of its recurrence, and the amplitude of the alternate rise and fall, the daily record of the barometer is carefully examined, and, whenever the phenomenon is found clearly defined, the hours of the two extreme lowest and two extreme highest readings, together with the readings themselves, are noted and tabulated on the blank. To save repetition, I will state here that all compilations of the barometer are reduced to 32° Fahr. and sea-level. As two more items of interest, the highest and the lowest readings of the barometer and dry-bulb that occurred during the whole time the ship was in the square are noted and entered. A miniature chart of a five-degree square, but on a sufficiently large scale to allow of considerable accuracy, is printed on the *Form*, for plotting the ship's track: the position of the ship being determined at 8 A. M., noon, and 8 P. M. of each day, these points afford the data for tracing the track. Whenever currents exist, their set in points and their velocity in knots and tenths of a knot per hour are written on this little chart at each noon position; an arrow is also projected from the track to indicate their direction. At every noon the temperature of the sea-water at the surface is very carefully taken, and entered on the chart on Form B, beside the noon position of the ship; it assists in coming to a conclusion as to the existence of currents.

This completes the tabulated portion of the compilation on Form B; but, to unite the whole, to trace the connection of the several related quantities, and to describe such matters as could not be otherwise noticed, ample remarks are made on the blank.

Thus, at a glance, are all the observations of a ship in each square visible on a single sheet; it is not assumed that what she experienced prevailed over all the expanse of the square; her track lies before us on the little chart that represents that square, and the tabulated observations beside it relate to that track only — a single line! If we have the observations and tracks of a large number of vessels, all over every part of a five-degree square for *each month*—in other words, if we have a multitude of sheets of Form B compiled—it is evident that we can easily deduce the meteorological features of that square, and judge whether they be like or dissimilar throughout its entire extent.

To follow up the fate of Form B, compilations having been made on many thousand sheets of it from all the log-books and journals that could be obtained relative to the expanse of ocean under consideration, the next step is to classify these, and to reduce the observations. The classification consists in grouping together all the sheets of the same square for the same month, without distinction as to year or ship; and, to reduce, all the observations on the blanks of each group are first transcribed to a single sheet of another blank, *Form D*—a kind of ledger, as it were, to which the separate sheets of Form B bear the relation of so many entries in a day-book.

It may not be entirely devoid of interest to some of my readers, to have here such a description of Form D as will enable them to reproduce it: a fac-simile before one would render the details of the reduction more easily intelligible.

At the top of the form are spaces for entering the number of the square and the name of the month. Under this are six vertical columns crossed by thirty-four horizontal lines. The headings of the columns in succession, from the observer's left to right, are as follows: 1st column, "Total No. of hours of wind from every alternate point"; 2d, "No. of hours of wind from every point"; 3d, "True direction of wind" (under this heading the points of the compass, beginning with north, are printed—one point on each line—down the first thirty-two lines of the blank, and "calms" and "variable winds" are on the last two lines); 4th, "Mean force of wind from every point"; 5th, "Final mean force of wind from every alternate point"; and, 6th, "Percentage of wind from every alternate point."

To illustrate the use of Form D, suppose that for any square for any month—say No. 643 for July—there are fifty sheets of Form B. To collect the numerous observations of the wind scattered throughout these, each point is considered separately and in succession. The sum of the different periods that the wind was of the same force from the same point on all the sheets of Form B is found; the direction of the wind on this Form being magnetic, it is corrected for the variation of the compass, and then the sum is entered on Form D opposite that point which it becomes as a true direction.

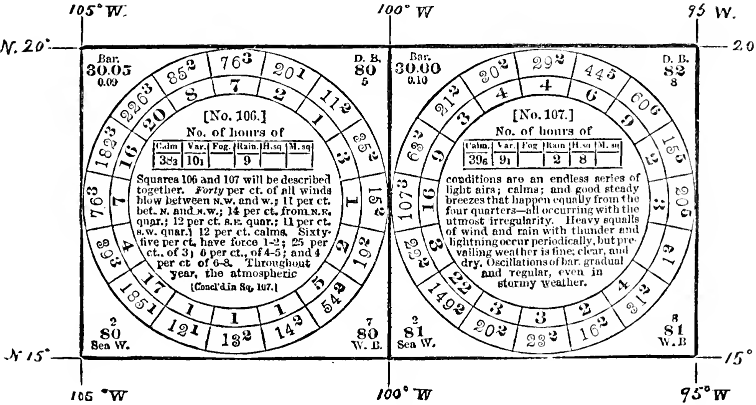
Take a specific case, and let it be the magnetic north of Form B, with the variation one point westerly for the square under reduction: suppose that all the hours the wind was a force of 5 amounted to 80; then "80" would be entered in the 2d column, and "5" in the 4th column of Form D, on the horizontal line on which "N. BY W." is printed; because a magnetic north wind becomes a true north-by-west wind when the variation is applied. Again, if all the hours the wind was of another force, say 3, from the same point (magnetic north) amounted to 120, then "120" would be placed in the 2d column, on the right of the previous sum 80, and "3" in the 4th column, on the right of the other force, 5. Similarly, with all the hours of each force, and with every point of the compass, the order being preserved throughout of having the first sum of hours in the 2d column correspond with the first force in the 4th column, the second sum of hours with the second force, and so on.

As the direction of the wind is given on the charts for only the *alternate* points, the observations of the intermediate points are distributed among those adjacent. Suppose the transfer of the observations of the sheets of Form B, for one point, to stand on Form D thus: 80 + 120 + 300 + etc. . . . (hours) . . . . N. by W. . . . 5; 3; 2; etc. . . . (Force). The point N. by W. not being used, all these observations must be distributed between North and North-northwest—half to each: i. e., 40 hours, force 5; 60 hours, force 3; and 150 hours, force 2, must all be placed opposite North, and the same opposite N. N. W., just as if they had come from the sheets of Form B. The "*Total* No. of hours of wind from every alternate point" is now found by adding up the separate periods, and the sum is placed in the 1st column opposite its own point. To obtain the mean force for this sum, each separate period of hours is multiplied by the force peculiar to it, the products are added together, and their sum is divided by the "Total No. of hours of wind from every alternate point"; the quotient is the "Final mean force," which is accordingly placed in the 5th column. The totals of "Calms" and of "Variable winds" are now found, and carried out to the 1st column; then all the figures in this column are added up, and the result is the "*Total No. of hours of winds, calms, and variables*" observed in square No. 643 during the month of July. To complete the treatment of the winds, the percentage that the total number of hours from every alternate point, as well as the percentage that the calms and the variables are of the total number of hours of observation in the square, are worked out and entered in the 6th column.

On the back of Form D are columns for collecting the other data scattered over the sheets of Form B, viz.: 1. Barometer and thermometers. Beside the mean of each of these quantities transcribed from Form B is placed the number of hours of observation from which that mean is deduced, so that, in obtaining the *final mean* of the square for the month, due weight can be given to each individual mean. 2. The separate mean daily ranges of the preceding items, with the number of days of which the mean is formed written beside it; 3. The regular daily oscillations of the barometer; 4. The highest and the lowest readings of the barometer and dry-bulb, with the period during which each separate observation was made; 5. The total number of hours of fog, of rain, of squalls (heavy and light), and of gales from each quarter, with their strength; and, 6. A summary of the currents, weather, and magnetic variations. To complete Form D, a *résumé* of the remarks on the various sheets of Form B is made—a generalization of the experiences of the several ships—and transcribed to the back of the form. When the observations of *every* square for *each* month are collected on sheets of Form D in the manner described, the reduction of the data is complete for the part of the ocean under consideration. The final step is to arrange the matter in shape for the engraver and printer. This is done on sheets of Form C—a blank eight inches by ten—which is a fac-simile of one of the squares of the monthly charts enlarged to a size suitable for writing all the data in the proper spaces. The data for all the squares for one month are transcribed from Form D to Form C; these are sent to the engraver; a proof-sheet comes back in due time; this is read and corrected; and eventually the charts themselves issue complete from the press. Until the year 1876 no systematic use was made of the log-books of our vessels of war. Every six months they were sent from each squadron to the Navy Department, where they have been accumulating since the days when Maury had the supply then on hand compiled for his charts.

Now, a large number await examination—a rich mine of valuable material. A set of charts for the Pacific Ocean between the equator and latitude 45° north, and from the American coast to the 180th meridian, are the first fruits of labor in this mine. The complete set consists of fifteen different sheets: 1. Twelve on which the information peculiar to each month is given on a separate sheet; 2. One that summarizes all the observations of the direction and force of the wind of every month and year; 3. One that similarly gives all the observations of the barometer, thermometer, and weather; and, 4. One in colors showing the wind systems, stormy regions, and areas of equal heat and equal pressure—a graphical exhibit of what the other charts contain.

Preceding the set are, a table giving for every month the latitude and longitude in which each ship entered or lost the trade-winds; a list of the log-books whose data enter into the charts; and a preface chiefly descriptive of the method of compilation. All are printed on thick paper and bound together in a folio volume convenient for use.



The method of compilation having been described, the charts will now be easily understood.

The figure on page 191 is a fac-simile of two adjoining squares of a monthly sheet—February. They cover the small area of ocean west of the Mexican coast between the parallels of 15° and 20° north and the meridians of 95° and 105° west. The month and square constitute jointly the unit for which all the information is given; for some squares this is meager, for others full—always dependent on the length of time ships were in the square and the number of log-books examined for it.

The explanation of one of the above squares—No. 106—will afford a key to the whole series. The figures inclosed by circles relate to the winds; those between the outer and the middle circle indicate its duration and force; and those between the middle and the inner circle, its percentage, from every alternate point. The points are inclosed by parts of radii that extend from the outer to the inner circle: thus, the two radii opening toward the upper left-hand corner, and containing the figures $\frac{226^{3}}{20}$ *inclose* the N. W. point; the two containing $\frac{85^{2}}{8}$ inclose the N. N. W. point, and so on to the right through North, N. N. E., etc. If we add together the hair-line figures between the outer and the middle circle, as 226, 85, 76, etc., they will amount to 1,062; add to this the figures under the heading "calm" (38), and "var." (wind) (10), and the total is 1,110. This means that if the hours all the vessels spent in the square were added together, the total would be 1,110 hours, or 46 days 6 hours; this is the whole period of observation in this square for this month; it is composed of fragments of February collected from many years. An hour is the unit of observation, and a vessel had to be a whole hour in a square in order to have it constitute an observation. In this square, then, there were 1,110 observations of the wind: of this number, it was 226 hours from the N. W.; 85 hours from the N. N. W.; 76 hours from North, etc. The small dark figures to the right of the hair-line figures indicate the force of the wind: thus, the 3 annexed to 226 signifies that the mean force for those 226 hours was 3, according to the scale already given. The number of hours of wind from any one point may have been the experience of one or several vessels; and that number may be composed of hours of light, gentle, fresh, and strong breezes; but, however such variations may have occurred, the mean force is indicated by the small dark figures.

It would, no doubt, be desirable to give the percentage of *different* forces of the wind from each point, but this would greatly detract from the simplicity and ease of consultation of the charts. The defect is, however, approximately met by giving, as is done, the extreme variations of the wind, i. e., the number of calms as well as of heavy squalls and gales. The figures between the middle and the inner circle denote the percentage of wind from every alternate point: thus, of the 1,110 hours of observation, the wind was 20 per cent. of the time from the N. W.; 8 per cent. from N. N. W.; 3 per cent. was calm; and one per cent. light variable winds. The little table below the number of the square is to be read thus: of the 1,110 hours, 30 were calm; 10 were characterized by light airs flying all round the compass; no fog; 9 hours were rainy; no heavy squalls; and no light squalls. In the upper left-hand corner is the mean of the barometer, 30·05—the mean of all the hourly observations taken in the square during the month; under it is the mean daily range, 0·09 inch—the mean of the differences between the daily maxima and minima for 46 days. In the upper right-hand corner, under D. B. (dry-bulb) is the mean temperature of the air (in the shade), 80° Fahr.; the 5° under it is the mean daily range, both means obtained as for the barometer. Similarly, in the lower right-hand corner, is the mean temperature of evaporation and its daily range; and, in the lower left-hand corner, the mean temperature of the sea-water at the surface and its mean daily range.

The remarks within the circles are drawn from the experience of all the vessels that passed through the square in all the months of the year. It is their aim to fill up the outline character of the square afforded by the figures. While these remarks run through all the squares that have sufficiently similar features to be described together, the figures are applicable only to the square and month in which they appear. Thus are the climatic features of each small area of ocean delineated.

It should be understood that these charts merely exhibit the experience of the past reduced to a scale of probabilities for the future: if, then, the conditions stated in any square be not exactly realized, the system should not hence be condemned.

Let any navigator consider the degree of dependence he will place on a trustworthy record of a passage he once made; the confidence with which he will refer to that record—to the experience of a single voyage!—for his guidance in traversing the same ground again: now, it is not the record of one passage alone, but of many—all conveniently arranged, with every discernible error and inaccuracy eliminated—that is given in any square of these charts.

As a fair way of regarding them, let us consider the data of the square 106: of the 1,110 observations of the wind, it was 226 hours, or 20 per cent. of the whole time, from the N. W.; hence, at any future time, there are twenty chances for a N. W. wind of a force of 3, against eight for a N. N. W. wind, force 2; against seven for a N. wind, force 3; against three for calms and one for very light airs.

The observations of the *direction* of the wind on Maury's pilot charts have been incorporated with those extracted from log-books and journals of recent date, and, although they outnumber the latter, still they do not form the basis of the charts. That basis is the variety of observations compiled and reduced in the careful and laborious manner already described, and which have then been examined from every standpoint to elicit whatever beam of information they might contain to illumine the ocean highways. Therefore, in justice to the amount of thought, care, and labor bestowed on these charts, it must be stated that they are *not* a rearrangement of old matter, but are essentially new, and from original sources.

The second series of charts (now in course of compilation) embraces a series for the whole Atlantic between the parallels of 60° north and 60° south. The observations of the *direction* of the wind on Maury's pilot-charts, to the number of about 2,600,000, or 300 years, will be embodied in them: the actual period over which these observations extend is from the year 1800 to 1855. But, as with the Pacific charts, the real groundwork of the Atlantic series is the various kinds of observations at present compiled in the careful manner already described from recent log-books and meteorological journals. In number, these observations will amount to about 650,000 hours, or 75 years. The actual period over which they will extend is from the year 1855 to 1881, the time when it is confidently hoped this set will be ready for issue. By far the greater part of the compilation is already done. The Atlantic charts, then, will contain hourly observations to the number of about 3,250,000, or nearly 375 years: in other words, if it were imposed on a *single* ship to collect this mass of data, she would have to cruise in all parts of the Atlantic during every month of the year, for a period of 375 years, without ever going into port!

As, however, these observations were collected by a multitude of vessels and during a *continuous* series of 81 years, several vessels were observing at the same time in different parts of the ocean. Surely, this is an abundance of facts that must render indisputable the information contained in the more frequented squares: more would be mere accumulation, without perceptibly affecting the mean results.

On some accounts it would be desirable to have the areas for which the information is classified smaller than 5° squares, as 1° squares, for example; but, again, there are objections, all but insuperable, to such a system:

1. To collect data for it sufficient to give trustworthy results, would require a fleet of cruisers almost as large as the combined merchant marine of the world—all to be assiduously engaged for many years. This is unattainable. Even with the inducements now offered, and notwithstanding that the undertaking is mainly for their benefit, only a very small percentage of all the masters of merchant-vessels will take the trouble to keep a meteorological journal with the requisite accuracy and care. Were it not for the excellent log-books of our ships of war, our knowledge of the phenomena of the ocean would indeed be most meager and inaccurate.

2. Supposing the data obtainable, the organization essential to dealing with it in such detail would be immense: a lifetime would hardly suffice to reach a practical result.

3. Its publication would require five times as many volumes as the present system—a series already bulky enough to deter any one from increasing it.

4. Throughout by far the greater part of the ocean, the several quantities do not vary rapidly enough to warrant compiling them for such small areas.

The prevailing direction and force of the wind are substantially the same in many adjoining 1° squares; and so also are the pressure and temperature of the air, the weather, etc.: therefore, to classify them for 1° squares would only be multiplying what, for the most part, was equally applicable to the whole extent of a 5° square.

Besides, the object sought by the 1° system, the determination of the well-defined limits of the different phenomena, is more accurately attained by a method pursued in connection with the 5° system: on a Mercator's projection of very large scale, all the observations relating to one subject of inquiry are plotted in the position where they were observed. For example, the winds: at each noon position of the ship, an arrow is drawn to indicate its direction, and a small figure placed beside it to denote the force; a circle represents calms, and several short lines radiating from a point, light variable airs.

This continued until the whole sheet is studded with symbols, it is evident that we can determine, not to the closeness of one degree only, but to within a few miles, the precise area covered by the trades, or calms, or monsoons, or irregular breezes. The observations of the temperature of the air, of the sea-water, and of the barometer, are all similarly plotted, each on a sheet by itself. In every instance the symbols are in different colors, to distinguish the data peculiar to each month.

In order to determine with the greatest possible precision the limits of the Gulf Stream, as well as the veins of varied temperature that permeate it, a separate sheet for each month on an unusually large scale is provided for the observations relating to it.

It might seem that, instead of publishing such elaborate charts as the series described, a single sheet containing merely the conclusions arrived at would suffice—a chart showing those courses from port to port on which the most favorable winds and weather would be found. As well lay railway-tracks over the ocean and expect ships to glide upon them! In matters pertaining to their profession, none are more tenacious of their opinions than sailors—and justly so: they form them after hard experience. To dislodge those opinions it must be proved wherein they are faulty and others correct; and this can not be done by mere results. To lay down a rigid rule for a man to follow is to deprive him of the exercise of discretion and judgment—qualities in which it is eminently proper a sailor should be untrammeled. No, a track-chart is a useful auxiliary—it partly solves the problem of tracing the best course from port to port, and such a chart will eventually form part of the entire set; but a full exhibition of all the data on which the judgment is based is essential to every intelligent seaman.

It is the log-books of ships of our own navy from 1855 to 1877—the large accumulation of twenty-two years—that are now undergoing compilation at the Hydrographic Office for the series of charts described: since 1877, by an order of the Navy Department, the compilation is made by the navigator of each cruising ship. Being an officer of many years' experience at sea, and having direct and daily supervision of the log-book, there is great advantage in having the data arranged in the requisite form, on the spot and at the time of its occurrence, by such a competent person.

Both the observations and compilations are made with a definite object in view, and, as that is to furnish charts for their future guidance, it is an incentive to the officers engaged in their preparation to make them as trustworthy as possible. The compilation is to continue until charts for all the frequented portions of every ocean are published.

When a log-book is full, both it and the compilations are sent to Washington, where they are examined, compared, and used as found necessary.

In an article in a former number of this magazine, I have said that it is impossible to predict, as is done on the land, what the weather will be in various parts of the ocean for any short period; there we lack the stationary points of observation with direct and instant communication: as pointed out by Maury, the most that can be done in this way is to warn European countries by telegraph of the approach of storms that traverse the Atlantic from the American Continent; and of late this has been successfully done by the "New York Herald."

In conclusion, I will merely allude to the utility of the charts that form the subject of this article. If, on land, it be optional to choose one's residence according to the salubrity of the climate, so at sea, the mariner, with a panorama of the winds and weather spread before him, can direct his course through only those squares that are favorable and avoid the stormy.

Moreover, the novice to the sea or the philosopher in his study can, by a mere inspection of them, see what has passed over the waste of waters during the last hundred years, and be more fully and accurately informed regarding what in all probability he would have to encounter, in the way of aërial phenomena in an ocean-voyage, than the most weather-beaten tar that plows the main.

FIRST-HAND AND SECOND-HAND KNOWLEDGE.*

By W. B. DALBY, F. R. C. S.

IN every system of education in which natural science forms no part, whatever knowledge the pupil gains is acquired from what he reads or from what he is told, and the truth of facts so presented to him he must take either upon trust or, in so far as they can be demonstrated to his reason, by logic or mathematics. In the study of natural science, on the other hand, he sees, he feels, he hears the same fact repeated again and again under the same conditions; and his informant is Nature—Nature, who never errs. Which is the better mode of acquiring information? Which information is the more likely to be true, to be the more worthy of trust, and safer to be acted upon? These questions need no reply. We shall all agree that one of the most important elements in education is English literature, and certainly in this department history must be included as not the least useful and delightful. But consider for a moment how entirely different, as a force in mental culture, is the information acquired by learning anything in science or in history. Take, for example, the character, or even the acts, of Mary Stuart. Although the events in her life occurred only some three hundred years ago, I dare say I could find among the students I am addressing as much difference of belief in many of her recorded actions, and certainly of opinion in regard to her character, as on any subject I could raise. To do this it would only be necessary to select a student fresh from the reading of Mr. Froude's history, and another who had derived his impressions from earlier histories, and had not laid aside the romance with which Scott's novels have surrounded this Queen. Mr. Froude's references to existing documents may be sufficient to induce me to receive his facts for purposes of history; but, accept his accounts as much as I will, my belief is of a very faint sort if I compare it with anything I have seen for myself. Viewed in the light of actual knowledge, the facts derived in the two ways have a different kind of value to me, both no doubt good in themselves, but still widely apart. With all due respect to the authorities at our old universities, I can not but think that the time will come when the elements of physiology and chemistry will be considered as valuable a method of mental training as the production of what are fancifully termed Latin verses, as the study of the traditional records of Jewish history, or the learning by heart of sentences from Paley's "Evidences." In the work which you now propose to undertake you will require no one's evidences but those of your own senses, and any statement from your teachers you will be able to subject to such tests. In whatever degree you do this your studies will be useful; when once

* Part of an address delivered at St. George's Hospital, London, October 1, 1879.

you omit this they will be feeble and barren in their results. When you read or are told that an artery pulsates, that it is composed of so many coats, each possessing peculiar properties and uses, you will see and feel the artery to beat, you will examine its coats, you will see their properties exemplified in life, in death, in health, and in disease: in health, when it is divided by the knife, or tied to arrest hæmorrhage; in disease, when it is the seat of aneurism and other changes. Of what service would it be to you to read of all this? You would be better almost without such miserably insufficient information. Besides, what you read may not be true; you will decide for yourselves whether it is or not. If you wish to see the result of an education which makes a man arrive at an opinion accurately, act boldly, display manual dexterity, and effect good results, you may see it in any of the surgeons while deligating an artery to cure an aneurism. Again, supposing you to have made yourselves acquainted with the most complete account of typhoid fever, and simply to have supplemented what you have so learned by looking at any number of cases, and hearing what others have to say upon them. Until you have tested for yourselves the truth of all that you have heard or read about the disease, your knowledge would be worse than useless, for you might fancy that you know something about it, and, armed with such conceit, have the effrontery to take charge of a patient so suffering. When you have seen patients every day from the beginning to the end of the fever, have taken the temperature of their bodies and noted its variations, become so familiar with their pulses that you recognize the period at which it may be necessary to administer stimulants, examined the excretions, watched the changes in symptoms, noted the effects of treatment, observed every detail in diet and nursing, made yourselves acquainted with the affections which the fever leaves behind, witnessed the modes of death with patients who do not recover, examined the *post-mortem* changes in those who die from it, and, lastly (most important of all) have discovered the source whence the fever arose—if you have done all these things, your knowledge of the subject will be real, and you will have learned that, though books have their uses, they should in science and medicine be only used for the purpose of directing attention to what is to be looked for, and as a means of comparing the observations of others with your own. Thus far, then, books may be relied upon and no further. If this be so, the very essence and goodness of a scientific education is lost when a student endeavors to pass his examinations by learning from text-books what he should have taught himself by observation, and from pictures what he should have learned from realities. Those whose information is so gained have seized the shadow instead of the substance, and their work will for ever bear the marks of their indifferent education.

The results of the two modes of acquiring knowledge will be seen in the different classes of practitioners which they respectively produce. In the first order is the physician who intelligently studies physiology, who recognizes in pathology what I would for the moment call an eccentric physiology; who says to himself when contemplating disease: "I here see such and such organs of the body out of order, such and such functions imperfectly performed; let me try to place these organs at rest, so that they may recover themselves (where recovery is possible) and perform, perhaps, in time their functions as heretofore"; who appreciates that in pneumonia the tendency is toward recovery when not interfered with, if the patient's strength is so supported that he can tide over the period during which the lung recovers itself; who sees in typhoid fever the same necessity for support, with the additional one of resting the intestine until the ulceration has time to heal; who, in the case of diseased kidneys, rests these organs by putting their work on to other organs, such as the skin and intestines, and allows no food which requires the special exercise of the kidneys for purposes of elimination. Similar management with other diseased organs. Here knowledge of physiology precedes knowledge of disease, and disease means to this physician disorded physiology. How different from the meddlesome apothecary of not long ago —never easy without he was pouring his medicines into his patient every few hours, having for every symptom a fresh drug which added to his patient's difficulties, and for every pain some outward application which increased his discomfort! Now, his modern counterpart is he who has learned chiefly from books and untrained observation what he knows of disease; for, please observe, that constantly seeing patients by no means implies that the faculty of accurately observing has been attained, and if this faculty is not acquired by a man early in life he will blunder on into old age. Such a one does much the same as his predecessor in a milder way when his first consideration takes the form of the inquiry, What is a good medicine for this, and what for that? He knows what will cure something or other, and so prescribes it. So well is what I am saying beginning to be understood that the very expression "cure," unless applied with a special meaning, as to an aneurism, a hernia, or the like, has become almost offensive, and will ere long be used only by the ignorant and pretentious. The physician does not pretend to cure his patients; he places them in the conditions most favorable to recovery, and is thus often the means of averting death and conducting them to health. You must not think that I am underrating the value of medicines; a large number of drugs we know well to be most useful and often necessaries in the treatment of disease, but the practice of ordering medicines to every patient who applies for relief is no longer the practice of physicians, although perhaps it may be followed by those who would on occasions be the last to resort to it, if they had the courage of their opinions. But pathology is better understood than it was a few years since, and with a more complete knowledge of morbid processes has come a corresponding knowledge of the frequent inability of drugs to control them; add to this that, with a fairly intelligent patient, the man who possesses an intimate acquaintance with the morbid change which produces the symptoms has the power of explaining his disease to him, and so successfully insisting upon the requisite conditions for treatment, irrespective sometimes of little, if any, assistance from drugs—such a knowledge can not be attained without a thorough scientific training, and I could multiply examples where this kind of education is as useful as it is to the physician.

At the risk of being tedious, I can not help repeating that the mental training which encourages the habit of careful observation, of accumulating facts, the reality and truth of which are tested by experiment, which sweeps away opinions based upon imperfect premises, which succeeds in leaving upon its pupil a profound regard for accuracy in all his work, must be a valuable addition to any course of education—an addition, for I should be sorry to urge that it was a complete substitute for any branch of knowledge except it be philosophy and metaphysics. How science has superseded philosophy was well told by George Henry Lewes when he wrote: "The method of verification, let us never forget, is the one grand characteristic distinguishing science from philosophy, modern inquiry from ancient inquiry. The proof is with us the great object of solicitude; we demand certainty, and, as the course of human evolution shows certainty to be attainable on no other method than the one followed by science, the condemnation of metaphysics is inevitable. Philosophy was the great initiator of science; it rescued the nobler part of man from the dominion of brutish apathy and helpless ignorance, nourished his mind with mighty impulses, exercised it in magnificent efforts, gave him the unslaked, unslakable thirst for knowledge which has dignified his life, and enabled him to multiply tenfold his existence and his happiness. Having done this, its part is played; our interest in it is purely historical."—*Lancet.*

EDUCATION OF BRAIN-CELLS.

By J. MORTIMER GRANVILLE, M. D.

THE very interesting and important case recently narrated by Professor Sharpey in this periodical* recalls one that fell under my own observation rather more than twenty years ago. I will state its principal features, without going into details, and then venture to make the two cases an occasion for a few brief speculations which I am desirous of laying before medical-psychologists, with a view to

* See "Popular Science Monthly" for August, 1879—article "Reëducation of the Adult Brain."

obvious practical inferences in respect to the treatment of what I conceive to be a not uncommon cerebral condition.

In 1858 I was requested to see a daily governess and teacher of music, who had been suddenly attacked with what was thought to be acute mania. I found a spare, somewhat angular, eccentric-looking young woman, aged twenty-six, in a state of great excitement, hysterical and choreic. Within a few hours—after a paroxysm of considerable violence, during which she talked and sang wildly and was with difficulty restrained by those around her—she fell into a state verging on suspended animation, which lasted a week. The skin was cold, and presented a dark, mottled appearance; the pulse was scarcely perceptible at the wrist; the breathing slow and seldom deep; there seemed to be complete loss of consciousness, and scarcely any trace of sensibility. The muscles were cataleptic, and the extremities dropped slowly when raised. It was barely possible to feed the patient by the mouth, by holding forward the larynx and placing the fluid far back in the pharynx with a spoon, when it seemed to flow down the œsophagus as through a flaccid tube. This condition, which was treated with the interrupted current from the occiput and nape to the hypogastrium, and mustard-poultices down the spine, subsided very gradually. Then came the state I am chiefly interested to note. There had clearly been an exciting cause for the attack in religious excitement, acting on a nervous system exhausted by protracted toil as a teacher.

When consciousness began to return, the latest sane ideas formed previous to the illness mingled curiously with the new impressions received, as in the case of a person awakening slowly from a dream. When propped up with pillows in bed near the window, so that passers in the street could be seen, the patient described the moving objects as "trees walking"; and, when asked where she saw these things, she invariably replied, "In the other gospel." In short, her mental state was one in which the real and the ideal were not separable. Her recollections on recovery, and for some time afterward, were indistinct, and, in regard to a large class of common topics which must have formed the staple material of thought up to the period of the attack, memory was blank. Special subjects of thought immediately anterior to the malady seemed to have saturated the mind so completely that the early impressions received after recovery commenced were imbued with them, while the cerebral record of penultimate brain-work in the life before the morbid state was, as it were, obliterated. For example, although this young woman had supported herself by daily duty as a governess, she had no recollection of so simple a matter as the use of a writing implement. When a pen or pencil was placed in her hand, as it might be thrust between the fingers of a child, the act of grasping it was not excited, even reflexly: the touch or sight of the instrument awoke no association of ideas. The most perfect destruction of brain-tissue could not have more completely effaced the constructive effect of education and habit on the cerebral elements. This state lasted some weeks, and the "recollection" of what had been "forgotten," to use conventional terms, was slow and painful, needing, or, as I would now say, seeming to require, a process of reëducation as distinct as (though, I judge, less prolonged than) that which proved necessary in the case detailed by Professor Sharpey. In the end recovery was mentally and physically satisfactory.

I can not assume that anything in these two narratives will strike the practical psychologist as novel, or of even unfrequent occurrence. The clinical aspect of such cases has been sketched times without number. Nevertheless they present features of interest, as viewed from an etiological standpoint, which may be worthy more than a passing notice.

Either of three conditions may, I believe, be set up by brain disturbance, or disease, causing "loss of memory": 1. Complete destruction of cerebral cells; 2. Withering or blighting, which amounts to obliteration of the cells without destruction of their nuclei;* 3. A suspension of function without arrest of nutrition, as though a particular area of the cerebral organism were thrown out of the circuit of energy.

In the first event there will be final effacement of the records of ideation. So far as the cells destroyed are concerned, they and their properties are lost for ever. If the functions previously performed by these strata or tracts reappear, it must be because some other part of the brain has taken up the business vicariously—as I believe is possible with nearly every function or manifestation of mental energy. In the second event, when the cells are withered but the nuclei remain, a new crop of cells may spring from the parent organism, and, after a lapse of time sufficient for development, the educationary record will reappear, the seed reproducing its kind, plus the effect of training and ideation. It may be that there will need to be so much reëducation as to cultivate the new growth, and perhaps a reimpression of purely objective ideas, but it may, and probably in the majority of instances does, happen that the new cells will be developed with all the characteristics of the old. In the third event recovery may occur instantly, almost at any moment, if the obstacle to communication is overcome or breaks down in convalescence, so that the isolated, but scarcely injured, congeries of brain-cells may again be energized. I speak of brain-cells instead of "nerve-molecules," because, even accepting the vibration theory, it must be assumed that the vibrating particles are cellular vital organisms.

Supposing the states I have described to exist, I venture to suggest that the development of a new crop of cells from denuded germs or nuclei will account for the facility with which reëducation, in cases like that described by Professor Sharpey, reproduces *knowledge*, even

* I use the term *nucleus* here and throughout in a non-physiological sense, simply to designate the seat of life in a cell, whatever that may be.

at a period of life when it is not easy to learn. What the new training and teaching does is not so much to impart information as to foster the growth of a new crop from the old seed, just as an after-crop may be procured by breaking up an overstocked soil and applying the stimulus of manure. It is always possible that in the first process of instruction more seed may have been sown than germinated. Some good mental seed doubtless falls on barren ground, and it is perhaps due to the vitality and subsequent germination of this seed, that ideas which we do not seem to have cultivated deepen as the years go on.

Meanwhile I fancy it is as the progeny of old nuclei that the physical bases of a revived memory are restored during general recovery in cases of the class before us. It seldom happens that the reëducating process needs to be very explicit or prolonged. Far less teaching than would have sufficed to implant the knowledge originally will cause it to reappear. In cases where the cells only are destroyed and their centers of vitality remain, it may even happen that the mere establishment of health will suffice to bring about complete restoration. When the new cells grow, the old memories will be revived. This is what takes place in ordinary cases, when, although no especial pains are taken to reëducate, the "lost" knowledge returns. The completeness of the recovery will probably depend on the vigor of the first growth, and is doubtless governed by the same law which determines permanence or tendency to revert to an old type in the propagation of recently impressed or acquired qualities of species or family. Ideas, or an organic tendency to form particular conceptions, are certainly transmitted from parent to child. The cells first developed in a fœtal cerebrum are probably imbued with the qualities and properties of the brains of the mother and father, in different proportions. The transmission of germs of mental character which slumber through one generation and awaken with all their ancestral energy in the next is a recognized fact. It will therefore probably happen that the new crop does not at first present all the features of that which was blighted by disease, but develop part of its characteristics later on. Thus vigorous health at an advanced period of life will sometimes produce a perfecting of the recovery commenced, but not consummated, years before.

Cases of the first and third class are very likely to be confounded in practice. Final destruction may be assumed when, perhaps, a tract has been isolated without being destroyed. In this way I venture to think hopeless dementia is occasionally diagnosed, when what has happened is the disconnection, or throwing out of the circuit of cerebral energy, of a particular tract or stratum of element; and, unless watched, partial recovery, susceptible of treatment, may happen without being observed and helped at the critical moment.

Treatment for the first class of cases is valueless; for the second, the cure must consist in the reproduction of brain-cells, or rather, as I have suggested, the development of a new crop from the denuded nuclei of blighted cells. The so-called "reëducation" is only in a limited and scarcely physiological sense educationary. It is a repetition of the training, not so much to teach as to stimulate the growth of new organic elements from preëxistent germs imbued with formative forces and characteristics which must themselves determine the physico-mental result. If new cells *are* produced, they will be found already educated, that is, endowed with inherited characteristics which constitute the physical bases of memory. The educated germ naturally produces an educated cell. Upon this hypothesis rests the whole theory of heredity, species, and transmission.

In the third class of cases, recovery occurs as an accident of treatment, except when in the presence of a constitutional cachexia like syphilis, specific medication may remove the grip of disease which, so to say, holds the mental organism in fetters that its energy can not act. It will, I think, be often found that the seemingly permanent losses of memory which occur after acute disease are due to the isolation of special strata of cerebral tissue by the stasis of syphilitic or gouty disease. Mercury, iodide of potassium, or colchicum may in this way serve as a "memory-powder," and work a cure.

The two points I am chiefly anxious to place on record, without any claim to novelty of suggestion, are, first, that what is called reëducation is often simply the fostering of a natural growth—never harmful unless overdone, but of less value than may at first sight be supposed; second, that, in the absence of special indications that what seems to be helpless dementia is actually what it seems, i. e., a physical destruction of brain-cells, it is always *possible* the patient may recover, and therefore never justifiable to write a case off as incurable, and leave it to drift unnoticed and unhelped.—*Brain.*

EARLY METHODS IN ARITHMETIC.

By E. O. VAILE.

IN our day arithmetic is looked upon as a science of which every boy at fourteen ought to be master. Such was not the case a century or so back. In England, as well as upon the Continent, arithmetic was long considered a higher branch of science, and a university study, like geometry. In part, this is accounted for by the strong conviction which has always possessed mankind until within the last two hundred years, that numbers have about them very potent and mystical properties. During the middle ages this science had its skilled professors. The partial title of a work gives an idea of its exalted claims even after the time of Shakespeare and Bacon. The book appeared in London in 1624. Its title-page read thus: "*The Secrets of Numbers* *according to Theological, Arithmetical, Geometrical, and Harmonical Computation. Pleasing to read, profitable to understande, opening themselves to the capacities of both learned and unlearned; being no other than a Key to lead Man to any Doctrinal Knowledge whatsoever."*

But, in addition, there was difficulty and complexity in the science as practiced then that made it no boy's play. Even making allowance for the great advantage of "being used to a thing," the middle-age processes in the fundamental rules were often much more intricate than those practiced nowadays. In his incomparable history of the science of arithmetic, in the "Encyclopædia Metropolitana," Dr. Peacocke gives many interesting illustrations, some of which will doubtless strike the reader as novel. Some of their steps are easily explained, but others are by no means so simple. It might prove of interest and advantage to test the higher grades in some modern schools in regard to their actual comprehension of the first four rules by requiring them to explain the philosophy, not the process merely, of a few of these mediæval "sums." Explanations further than a description of the process are purposely omitted.

In subtraction they usually began at the left hand instead of the right. Inconvenient as it is, the method was continued as late as the end of the sixteenth century. The difference was placed above the numbers instead of below.

Process.
18769 remainder.
54612 minuend.
35843 subtrahend.
1111

EXAMPLE 1. Subtract 35843 from 54612. When the digits in the subtrahend are greater than those in the minuend, units are placed beneath them as in the example; 3 being increased by the unit in the next place to the right, and similarly for 5, 8, and 4.

Process.
06779 remainder.
2991
30024 minuend.
23245 subtrahend.

EXAMPLE 2. Subtract 23245 from 30024. Of course with such an arrangement it is of no consequence whether the operation proceeds from right to left or from left to right. It will be easily seen how the substituted minuend is obtained, with the exception of the one ten. Suppose the figure 4 in the subtrahend had been 1; then to what device would the boys and girls of the time of Luther and of Queen Elizabeth have had to resort to save their credit?

There is reason for thinking that the modern method of subtraction was the invention of an English mathematician of the first part of the seventeenth century, by the name of Gath.

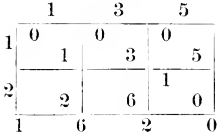
In multiplication there were some ten or twelve different processes in practical use; but, strange to say, our present mode is not found among them. A few of the subjoined examples are easily intelligible. A little study will make the others plain:

EXAMPLE 1. Multiply 135 by 12.

Process 1.

```
 1  3  5
12 12 12
--------
1 2   6 0
  3   6
--------
1 6 2 0
```

Process 2.



Process 3.

```
 135
  12
----
  10
  11
   5
  1
----
1620
```

The commentator considers this method as difficult, and not to be learned by dull scholars without instruction.

Example 2. Multiply 15 by 12.

$15 = 4 + 5 + 6. \quad 12 = 2 + 4 + 6.$

Process.

4 ,	5 ,	6	
2 ,	4 ,	6	
8	16	24	48
10	20	30	60
12	24	36	72
30	60	90	180

Example 3. Multiply 30 by 46.

Process.

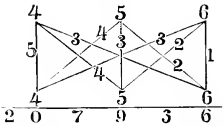
```
1610
  35
  ×
  46
```

This method was called "crosswise," from the manner in which the partial products to be added were obtained. It is not improbable that our present sign of multiplication was derived from the crossing of the lines in this process, as being somewhat indicative of the operation.

Here is a larger example worked by the cross-method:

Example 4. Multiply 456 by 456.

Process.



To indicate the successive steps the linking-lines are numbered, so as to show the groups in which the products are to be taken for addition.

Process.

```
   456
   456
------
207936
```

Let the products be found and properly grouped and added mentally, and one will better appreciate how much we depend upon mere mechanism in our own mental operations.

The method by the *little castle* was much practiced at Florence. Why the name was given to it is not very clear.

EXAMPLE 5. Multiply 9876 by 6789.

Process.

```
9 8 7 6
6 7 8 9
-------
6 1 1 0 1
  5 4 3 1 2
    4 7 5 2 3
      4 0 7 3 4
---------------
6 7 0 4 8 1 6 4
```

The method by the square was regarded as elegant, not requiring the operator to attend to the places of the figures.

Process.

```
     9    8    7    6
     6    7    8    9
 ------------------------
| 8 | 8 | 8 | 8 | 4 |
|---|---|---|---|---| 4
| 7 | 9 | 0 | 0 | 8 |
|---|---|---|---|---| 6
| 6 | 9 | 1 | 3 | 2 |
|---|---|---|---|---| 1
| 5 | 9 | 2 | 5 | 6 |
 ------------------------
   6    7    0    4    8
```

Latticed Multiplication.

Process.

```
      9     8     7     6
   ------------------------
        1     2     3     4
  9  8     7     6     5
   ----- ----- ----- -----  4
        2     4     6     8
  8  7     6     5     4
   ----- ----- ----- -----  6
        3     6     9     2
  7  6     5     4     4
   ----- ----- ----- -----  1
        4     8     2     6
  6  5     4     4     3     8
   ------------------------
      6     7     0     4
```

Some authors wished to elevate the character of the study, so as to save the labor of carrying tens. Here are two processes, or rather one process under different forms, which save that labor :

EXAMPLE 6. Multiply 234 by 234.

EXAMPLE 7. Multiply 5142 by 43.

Processes.

Ex. 6.	Ex. 7.
2 3 4	5 1 4 2
2 3 4	4 3
4 6 1 1 6	1 0 6
6 8 2	1 5 3 2
1 2	1 0 8
9	2 0 4 6
8	2 2 1 1 0 6
5 4 7 5 6	

Though the multiplication-table was in use by the Arabians and Italians at an early date, no notice was taken of it during the middle ages in the rest of Europe. It may give us more charity for the boys and girls who are now wrestling with it—although nowadays it does not seem to require the struggle that it used to—to know that grown men, and wise men probably, sought for devices by which the labor might be avoided which we go through in childhood. Outside of Italy, many writers considered it necessary to relieve the memory from retaining the products of digits above five. The principal rule—known as the "sluggard's rule"—given for this purpose during the last half of the sixteenth century, the half century after the time of Luther, Melanchthon, and Erasmus, was this: *Subtract each digit from ten, and write down the differences; multiply the differences together and add as many tens to their product as the first digit exceeds the second difference, or the second digit the first difference.*

Examples. $7 \times 8 = (3 \times 2) + (7 - 2 = 5)$ tens $= 56$.
$6 \times 9 = (4 \times 1) + 5$ tens $= 54$.

The method which we call short division was largely used in the middle ages, as was also the method of dividing by using the factors of the divisor. The process by long division was known, but was not so commonly used as others. It was called the process "by giving," since after subtraction we give or add (bring down) one or more figures to the remainder. Here is an example set down after the fashion of those times:

EXAMPLE 8. Divide 97335376 by 9876.

Divisior.	*Provenicns.*
9 8 7 6	9 8 7 6
9 7 3 3	5 3 7 6
8 8 8 8 4	
8 6 5 1 3	
7 9 0 0 8	
7 5 0 5 7	
6 9 1 3 2	
5 9 2 5 6	
5 9 2 5 6	

De Burgo, the most noted mediæval writer on arithmetic, thinks this last process—our long division—much less pleasant than the following method. Surely *tempora mutantur, et nos mutamur in illis.*

EXAMPLE 9. Divide 97535399 by 9876.

```
    1 5
    7 6 5
    8 2 9
  1 4 5 4 4
  8 6 1 0 2 2
  9 7 5 5 6 5
1 6 3 0 1 3 7 3
9 7 5 3 5 3 9 9 | 9 8 7 6
  9 8 7 6 6 6 6
    9 8 7 7 7
      9 8 8
        9
```

In this work the divisor is placed next below the dividend, and removed one place to the right since it is not contained in the first four figures of the dividend. The process with the first figure of the quotient, placed as usual at present, is as follows: The first number of the divisor, 9, is contained in 97 nine times with a remainder 16. The first figure of the divisor having been used is canceled; as are also the first two figures of the dividend. (The "scratches" or canceling-marks are omitted in the illustration.) The remainder, being of the same denomination as the first two figures of the dividend, is put directly above them. The next number to be used is 165. Multiplying the second figure of the divisor, 8, by 9, and subtracting from 165, 93 remains; 165 and 8 are now canceled, having been used. The remainder 93 is placed above in the proper orders, the 6th and 7th places. So it continues, leaving, after completing the work with the first figure of the quotient, the remainder 8651399. The divisor is now set down again, taking one place to the right as it should to correspond to the highest order now in the dividend; the last figure being raised to the line above, probably for symmetry. The process is continued as before.

All writers upon arithmetic appear to have agreed in commendation of this method as late as the end of the seventeenth century. It was, in fact, the only method thought necessary to notice. The English arithmeticians, from evident cause, called it the "scratch way" of division. Our present method was known specifically as Italian division, and was not introduced until the beginning of the last century.

One writer on arithmetic, a pious monk, furnishes a good illustration of mediæval logic. He is embarrassed by the usage and meaning of the term "multiplication" in the case of fractions in which the product is less than the multiplicand, and he proposes the question, "Whether the multiplication of fractions is an increasing process?" In order to prove that to multiply means to increase, he bases his argument on Scripture, and clinches the whole by quoting the promise to Abraham, "I will multiply thy seed like the stars of the firmament." To this devout logician there would be no joke in the common conundrum that proves Abraham to have been a mathematician because he increased and multiplied on the "face of the earth." But how is this to be reconciled with the numerical result in the cases under consideration? He supposes the units of the product to be of greater virtue and significancy than those of the factors: thus, if $\frac{1}{2}$ and $\frac{1}{2}$ represent the sides of a square, their product will represent the area of the square.

The first actual mention of real decimal fractions is in a Flemish work published in 1590. There the mixed number 27·847 is written $2\overset{(0)}{7}\overset{(1)}{8}\overset{(2)}{4}\overset{(3)}{7}$. To the present advocates of the metric system it may afford encouragement to know that Stevinus, in this work, enumerates the advantages which would result from the decimal subdivision of the units of length, area, capacity, value, etc.

In 1619 the contents of the Flemish book were embodied in an English work—"The Art of Tens, or Decimal Arithmetike, exercised by Henry Lyte, Gent., and by him set forth for his Countries Good." After enlarging upon the value of his system to all classes, he adds: "If God spare me life, I will spend some time in most cities of this land for my countries good to teach this art. I hold the lively voice of a meane speculator somewhat practised, furthereth ten fold more in my judgement than the finest writer that is." Rather severe on those "meane speculators," his contemporaries, Francis Bacon and William Shakespeare.

SPENCER'S DATA OF ETHICS.

By ALEXANDER BAIN, LL. D.,

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IN the immense abundance of literary production a great deal of criticism is avowedly calculated to supersede the perusal of the works themselves. Such a book as the present, however, is among the rarest; and being on the most interesting of all themes, and withal lucid and short, the critic would be much mistaken in assuming that it will not be read by his own readers and many besides.

The field of ethics has been crossed and recrossed in many directions; and we are now called to follow a new and unbeaten track. Our interest and expectation are awakened, not simply on account of the general philosophic ability of the writer, which disposes us to listen to him on any topic that he may see fit to take up, but also because he regards the work before us as the end and outcome of all his labors, the object to which all the preceding parts of his systematic elaboration are preparatory. The philosophy of evolution, which he has spent his life in constructing, is here to reach its application to practice. With a view to the popularity of the work, this may seem a disadvantage, as comparatively few of those that are attracted to a book in morals have followed the author through his long precursory series of *magna opera*; yet the disadvantage is not so great as might be so supposed, for such is the expository clearness gained from long familiarity with the materials, that the work is self-explaining in a remarkable degree.

Although thus disclaiming the purpose of dispensing with the independent perusal of the work, yet without making a general survey of its plan and leading ideas I am unable to criticise any portion intelligibly.

The preliminary question necessarily is the definition or province of ethics. What is meant by conduct, and what by good and bad conduct? Conduct is the adjustment of acts to ends. As to good and bad, we must proceed systematically through the animal series; or trace the "Evolution of Conduct." The lowest creatures are characterized by insufficient adaptation of actions to the ends of existence; they move about at random, and live at the mercy of chance. But proceed upward from the infusorium to the rotifer, and we find the actions better accommodated to the situation, and as a consequence greater chances of preservation. Move still upward to the higher vertebrates, and look at the superiority of an elephant to a cod; go yet further, and compare the civilized with the savage man: we find the same expression to apply—the multiplication of activity in the serving of useful ends, whereby life is increased both in length and in breadth. Turn next to the conservation of the species by the treatment of the young, and we find the same progress; in the lowest creatures only one germ in ten thousand comes to maturity. Lastly, take into account the social situation, where individuals act and react on each other, whether for prey or for assistance. There is here a like progress, shown in the like results; in the lower stages, mutual destruction; in the higher stages, mutual coöperation, with greater security of life and greater amounts of enjoyment.

This survey being premised, let us ascertain the meanings of good and bad. A good action is one that subserves either individual life, or the rearing of offspring, or the interests of the society at large. The relatively good is the relatively more-evolved. The highest conduct of all is what best reconciles all the three ends. Having reached this point, the author asks, Is there any postulate involved in these judgments of conduct? and answers yes, namely, the question, Is life worth living? which question he briefly discusses, making out that both optimist and pessimist must assume that life is satisfactory or otherwise, according as it does, or does not, bring a surplus of agreeable feeling. He disposes of the ascetic theory as being the product of the inferior religious creeds; and in so far as any persons in the present day retain the ascetic view, he runs them into absurdity by asking what they mean by the virtue of administering to a sick person; is it to increase the pains of illness? He then reviews the ethical end expressed by "perfecting" one's nature, and shows that there is no other test of perfection than "complete power of all the organs to fulfill their respective functions." Then as to making "virtue" the standard, he criticises Aristotle and Plato, and finds that they are playing off juggles of language. He next argues that virtue could not be upheld as virtue unless on the supposition that it is pleasurable in its total effects. Again as to the "intuitional" theory, he shows that the holders can not, and do not, ignore the ultimate derivations of right and wrong from pleasure and pain. He admits, however, that there is still among us a survival of the devil-worship of the savage, seen in our delight in contemplating the exercise of despotic power—the worship that owns Carlyle as its prophet, disguising itself by denouncing happiness as pig-philosophy, and substituting "blessedness" as the end. So much for good and bad conduct.

In a new chapter, the author pursues the criticism of the ethical theories, under the title, "Ways of judging Conduct." As a preliminary remark, he shows us with what exceeding slowness the idea of *causation* has been evolved. He is struck with the fact that all the theories—theological, political, intuitional, utilitarian—are characterized either by the entire absence of the idea of causation, or by an inadequate presence of it. Thus the theory of the "will of God" originates with the savage whose only restraint besides fear of his fellow men is fear of an ancestral spirit. Now, the notion that actions are good or bad simply by divine injunction is tantamount to saying that they have not in their own nature good or bad effects. After reviewing Hobbes and the Intuitionists, he tells us that even the utility school is very far from recognizing natural causation. In other words, he enunciates his known principle, of which the present volume is the expansion, that morality is not an induction from isolated facts, but a deduction from the processes of life as carried on under established conditions of existence. The proof of this principle needs a survey of ethics under four aspects—Physical, Biological, Psychological, Sociological.

In the four chapters devoted to the survey, Mr. Spencer's ethical foundations are laid. To begin with the Physical view. This treats conduct as so much motion suited to its purposes by paying respect to the law of conservation of force; in which view the ethical progress is progress to duly-proportioned conduct; and that conduct is increasingly coherent and definite, increasingly heterogeneous or varied, and tending to balance or equilibrium. "Complete life in a complete society is but another name for complete equilibrium between the coordinated activities of each social unit and those of the aggregate of units." The author admits that there is some strangeness in thus presenting moral conduct in physical terms.

The Biological view takes account of man's nature as an organism, or an aggregate of organs, to be maintained in due condition by regulated exercise, rest, and nutrition, and as liable to disorder by excess or defect. According to this view, the moral man is he whose functions—numerous and varied though they be—are all discharged in degrees duly adjusted to the conditions of existence. It is immoral to treat the body so as in any way to diminish the fullness or vigor of its vitality. One leading test of actions is, Does the action tend to maintenance of complete life for the time being, and does it tend to prolongation of life to the full extent? This position is not simply the consequence of the necessity of living in order to be happy; it takes us up to the further doctrine that happiness is fulfillment of function in each and all of the organs. In fact, the law of pleasure and pain—connecting pleasure with vitality and pain with the opposite—is here invoked as an indispensable link in ethics, and as one of the ways of rendering the science deductive, and of superseding the laborious if not impossible calculations of empirical Hedonism. In this chapter Mr. Spencer illustrates the truth at great length as a practical and moral lesson, and one as yet very imperfectly apprehended. The dependence of the mental on the physical, so completely neglected by our forefathers in all but the most obtrusive instances, has been gradually receiving more attention, and Mr. Spencer will be hereafter distinguished for giving it an additional impetus, as well as for contributing to its more precise definition. It must necessarily enter more and more into the guidance of human conduct, and must to that extent become an ethical factor. The doctrine in his hands cuts closer than ever; he proceeds upon the assumption that pleasure points out the way to the healthy discharge of the functions, and pain to the opposite. He is not unaware of the exceptions, and regards them as an imperfection of adjustment destined to pass away as evolution reaches its term.

The Psychological view takes us to the genesis of the moral consciousness through conflict of states, and through the subordination of lower ends to higher. In order to this we must conceive pleasures and pains in the future, and by such conceptions hold in check all present urgencies incompatible with remoter interests. The yielding of the lower to the higher may, however, be carried to excess; the subordination is a conditional subordination. The pleasures of the present are not to be absolutely sacrificed to the pleasures of the future; the present is always to be counted at its own value in striking the balance. Mr. Spencer illustrates this by the practical absurdity of men living entirely for the future. The source of the feeling called moral obligation is now indicated. The essential trait being the control of some feelings by some other feelings, Mr. Spencer traces the different species of control from without, in political government, religious fear, and the general influence of society. All these have evolved with society, as means of social self-preservation. The penalties accompanying them impart the feeling of coercion ; in other words, the sense of moral obligation. At the same time we are not to exclude from the aggregate the earlier and deeper element of self-regarding prudence, based on the penalties of improvidence. But now the moral motive, arising at first from external sources, is destined to transformation when the individual mind is completely accommodated to the social situation. The higher actions required for the harmonious carrying on of life will be as much matters of course as are those lower actions prompted by the simple desires.

The Sociological view, already implied, is the supplement of the physical, the biological, and the psychological views. It teaches the modes of conduct for reducing individual antagonisms, and bringing about mutual coöperation. Out of this, by necessary deduction, we obtain the reasons for fulfilling contracts, for assigning benefits in proportion to services, which is Justice ; and further for the rendering of gratuitous services, in a certain degree, which is Beneficence. We see how social life is furthered, not merely by mutual abstinence from harm, but by exchange of services beyond agreement.

In a separate chapter, entitled "Criticisms and Explanations," Mr. Spencer compares his deductive theory of conduct with the utilitarian computation, as handled by Bentham, Mill, and Sidgwick. I will return to this on completing the survey of his entire scheme. His next chapter is an illustration of the dependence of pleasures and pains on the state of the organism, and is equally necessary for his purpose, as being the completion of the theory of pleasure. People have often supposed that pleasurable agents, such as sugar to the taste, are so by intrinsic and absolute quality, the same to all persons in all situations. This is soon shown to be a mistake ; and the opposite truth is one of great importance in the ethical point of view. Physical pain is immensely greater in a highly developed nervous system. Exercises that give great pleasure to some creatures give none to others ; the system being in the one case adapted to them, and in the others not. Emotions presuppose a suitable organization. Destructiveness will give way to amity, if the nervous arrangements for one are atrophied by disuse, and those for the other persistently exercised. The civilized man is distinguished by contracting the same delight in peaceful industry as the savage feels in war and the chase.

The next two chapters—"Egoism *versus* Altruism" and "Altruism *versus* Egoism"—are the most incisive in the whole book. The relation of altruism to egoism is subject to habitual exaggeration even to the extent of self-contradiction, and Mr. Spencer brings a rigid scrutiny to bear on the whole question. His position is—the permanent supremacy of egoism over altruism; and he elucidates this in his systematic way. He cites numerous striking examples to bring home the truth that the first condition of the performance of duty to others is the perfect vigor and competence of the agent's self. As a pertinent moral lecture, nothing could be more effective. He allows that his view is the one practically recognized among men, and only regrets that the nominally accepted beliefs should be at variance with it.

In the chapter on altruism, Mr. Spencer, by a review of the entire social situation of human beings, endeavors to assign the exact scope and value of our sympathetic regards. While avoiding all exaggeration, he proves by numerous and striking examples the value of altruistic conduct to all and to each. The dependence of egoism upon altruism tends ever toward universality, becoming greater as social evolution advances.

He next proceeds to consider the conflict of the two principles, which leads him a second time to discuss the utilitarianism of Bentham and John Mill. He inquires what guidance the principle of "the greatest happiness of the greatest number" offers (1) to public policy and (2) to private action; and pronounces it defective as undertaking an impracticable operation, viz., first to gather all the happiness of mankind into one stock, and then to apportion it properly among individuals. I doubt, however, whether either Bentham or Mill conceived the doctrine of utility as necessitating any such operation. The essence and strength of the doctrine seem to me to be brought out by Bentham's two negatives of it—asceticism and unreasoning sentiment; to both of which Mr. Spencer is as much opposed as Bentham. The positive expression—the greatest happiness of the greatest number—is not itself happy, and was ultimately reduced by Bentham to the simple expression, "greatest happiness," which in its convenient vagueness seems to defy hostile criticism. How the greatest happiness of mankind is to be arrived at remains open for discussion. There is a general agreement at the present day that the best course is for each individual to occupy a limited sphere without thinking of the universal happiness. Mr. Spencer seems to me to be arguing for several pages without an opponent. The expressions that he quotes from Bentham and Mill need to be taken along with their whole system, which is, to my mind, not so very far from Mr. Spencer's own. They would say that society should confine itself to protecting each man and woman in the pursuit of their own happiness in their own way. This is the text of Mill's "Liberty." I admit that they are not able to prove beyond dispute that the greatest happiness will be attained in this form; but, as far as the needful computation can be carried, they think it is in favor of such an arrangement.

The discussion has, at all events, been brought to the point of stating that ethics is a regulated compromise between egoism and altruism. What remains is to consider the possibility of an ultimate conciliation. The position at present being that egoism is too strong or altruism too weak, the conciliation must work by finding some means of strengthening the altruistic promptings. Mr. Spencer sees in the tendencies of evolution a progress in this direction. In an interesting dissertation on the sources of sympathy, he endeavors to point out that the faculty admits of development in two ways, viz., the natural language or expression of the feelings, and the susceptibility to that expression as witnessed. He expects such an increase in these two powers as to reverse the predominance of egoism, and to make altruism the prevalent fact of our constitution in minds generally, as it is at present in a few. There will then be as much competition in rendering services as there is at present in exacting them. Indeed, the difficulty will be to find scope for the altruistic cravings. The spheres finally remaining will be chiefly (1) family life, in which the care of children by parents and of parents by children will be better fulfilled, (2) social welfare, in the improvements of the social state, and (3) private relations, where the casualties of life will always afford occasion for help to the sufferers. "Far off as seems such a state, yet every one of the factors counted on to produce it may already be traced in operation among those of highest natures. What now in them is occasional and feeble, may be expected with further evolution to become habitual and strong; and what now characterizes the exceptionally high may be expected eventually to characterize all. For that which the best human nature is capable of is within the reach of human nature at large."

In a chapter entitled "Absolute and Relative Ethics," Mr. Spencer defines absolute ethics as formulating the normal conduct for an ideal society, such as we shall have in the future, and relative ethics as the science that interprets the phenomena of existing societies in their transitional states, laboring under the miseries of non-adaptation. The coexistence of a perfect man and imperfect society is impossible; and, could the two coexist, the resulting conduct would not furnish the ethical standard sought. Among people that are treacherous and without scruple, entire truthfulness and openness must bring ruin. "Hence it is manifest that we must consider the ideal man as existing in the ideal social state. On the evolution hypothesis, the two presuppose one another; and only when they coexist can there exist that ideal conduct which absolute ethics has to formulate, and which relative ethics has to take as the standard by which to estimate divergences from right, or degrees of wrong."

The final chapter—"The Scope of Ethics"—is the summary and outcome of the whole, and offers the easiest means of comparing the author's point of view with the prevailing theories. The ethics of personal conduct is the best defined of all, from the requirements being so largely affiliated upon physical necessities. If this ethics could be made perfectly definite, it would necessarily go a far way toward settling the social ethics, which is made up of individual interests, and has for its function the balancing of each against the rest. The first division of social ethics is Justice, which is the prime condition of co-operation. The final division is Beneficence, negative and positive, involving all those nice adjustments of egoism and altruism previously commented on.

While there are many questions of great interest propounded for debate in this highly original work, I must be content with adverting to what I gather to be the author's main position—the displacing of utilitarian calculation or empirical Hedonism by an ethics of evolution. Not that the acceptance of the evolution hypothesis is an essential preliminary; if it were so, a great many people would at once refuse a hearing to the whole speculation. The relationship of the physical and mental, taken as a matter of fact, is in reality the chief corner-stone of the whole erection.

Mr. Sidgwick, after stating the difficulties attending an empirical Hedonism, as a means of investigating right and wrong, examined the various alternative methods "of determining what conduct will be attended with the greatest excess of pleasure and pain, so as to dispense with the continual reference to empirical results, which it has been found so difficult to estimate with accuracy." In book ii., chapter vi., of his "Methods of Ethics," he took up Mr. Spencer's views as propounded in "Social Statics." To this chapter Mr. Spencer expressly replies in his "Criticisms and Explanations." The real reply, however, is the entire volume. We must peruse and assimilate the whole, before giving an opinion on the question as between evolution and empirical Hedonism. I had occasion to remark, in noticing Mr. Sidgwick's work ("Mind," vol. i., p. 185), that the Hedonic or utilitarian calculation admits of being helped out by a variety of devices such as to mitigate the apparent hopelessness of the problem. Every suggestion of this nature should be welcomed and made the most of. Now Mr. Spencer recasts the mode of propounding the problem, without altering its essential character as an inquiry into the best means of attaining happiness. But he does more than this. He provides certain new lights that were not possessed by the earliest theorists on the side of utility.

The comparison with empirical Hedonism is best taken in the personal ethics. It is admitted that a code of personal conduct can never be made entirely definite. "But ethical requirements may here be to such extent affiliated upon physical necessities as to give them a partially scientific authority. It is clear that between the expenditure of bodily substance in vital activities, and the taking in of materials from which this substance may be renewed, there is a direct relation. It is clear, too, that there is a direct relation between the wasting of tissue by effort, and the need for those cessations of effort during which repair may overtake waste. Nor is it less clear that between the rate of mortality and the rate of multiplication in any society, there is a relation such that the last must reach a certain level before it can balance the first, and prevent disappearance of the society. And it may be inferred that pursuits of other leading ends are, in like manner, determined by certain natural necessities, and from these derive their ethical sanctions. That it will ever be practicable to lay down precise rules for private conduct in conformity with such requirements, may be doubted. But the function of absolute ethics in relation to private conduct will have been discharged, when it has produced the warrant for its requirements as generally expressed; when it has shown the imperativeness of obedience to them; and when it has thus taught the need for deliberately considering whether the conduct fulfills them as well as may be."

Mr. Spencer's great advantage, then, consists in the primary and constant reference to the physical side of our being. For a very large part of our happiness, physical tests may be assigned; and the problem is transferred from the purely subjective estimates, which are so vague, to objective conditions which are comparatively well defined—from the inward and spiritual grace to the outward and visible symbol. The author's antagonism is not toward the utilitarians as such, but toward the almost universal disregard of physical conditions by our forefathers. He is not the first to call attention to this great desideratum; but he makes a more thorough and systematic employment of it for the ends of happiness. Lord Shaftesbury said long ago that there were among us human creatures in such vile physical conditions that even religion was not possible to them. It would not be difficult to assign the lowest pitch of worldly means compatible with the fair requirements of a human being. The settlement of this point precedes all computations of pleasures and pains; or rather it is a short cut to the goal. The utilitarian has more or less enjoyed the advantage, without being so fully aware of it as he might be; for he has not scrupled to use worldly abundance as a first rough test of well-being; and, if the test were only rigorous and thorough, there would be nothing perplexing in the Hedonistic calculation; it would be as simple as common arithmetic. Personal ethics would be, Make a sufficient amount of money: social ethics, Do not defraud any one, and be ready, on suitable opportunity, to help those that are in need. The Hedonistic difficulties begin where money gained and expended is not commensurate with happiness. Moralists in all ages (Aristotle perhaps excepted) have delighted to dwell upon the occasions where the two things are incommensurable. A better consideration of the human organism, supplying a better knowledge of physical conditions, explains many of the exceptions, and helps to reinstate the problem on a definite basis.

The best way to compare the two methods would be to try them upon some of the contested questions of life and society. Mr. Spencer incidentally overhauls a good many of the commonplace usages and views, and rectifies them upon his principles. He shows the absurdity of men living and working all for the future, and depriving themselves of nearly every present indulgence. He earnestly inculcates the necessity of counting the present loss in the estimate of the future gain. This, it might be said, is merely empirical Hedonism. So it is, with this addition, that loss of pleasure is loss of vitality; the question of pleasure and pain being now resolvable into the question, To be or not to be? Of course, such a sweeping doctrine is to be held with certain qualifications and exceptions; and the point is, Can these qualifications be rendered definite? A rule with well-defined exceptions is practically universal.

Without assuming that Mr. Spencer has propounded a new doctrine, the antithesis of the doctrine of utility, he may claim to have put forward a new point of view, in the working out of the doctrine; a point of view that does not admit of being reargued until it has been tried. Who shall say what amount of gradual transformation of ethical conceptions will follow from steadily regarding conduct under the lights that he has afforded? He will be a bold man that can treat the regard to the physical organism, its capacities and developments, as of no importance in the Hedonic computation; and, if it is of importance, Mr. Spencer shows the way to turn it to account.

The bright future of complete accommodation of man to his circumstances, brought about by evolution, is cheerful to contemplate; and, if it be a work of imagination, it is at least based on science. The socialism that Mill would work out by a long course of education is clinched, according to Mr. Spencer, by inherited modifications and material guarantees. Our fervent wishes are with both.—*Mind.*

HISTORY AND METHODS OF PALEONTOLOGICAL DISCOVERY.*

By Professor O. C. MARSH.

I.

IN the rapid progress of knowledge, we are constantly brought face to face with the question, What is life? The answer is not yet, but a thousand earnest seekers after truth seem to be slowly approaching a solution. This question gives a new interest to every department of science that relates to life in any form, and the history of life offers

* President's address delivered before the American Association for the Advancement of Science, at Saratoga, New York, August 28, 1879.

a most suggestive field for research. One line of investigation lies through embryology, and here the advance is most encouraging. Another promising path leads back through the life-history of the globe, and in this direction we may hope for increasing light, as a reward for patient work.

The plants and animals now living on the earth interest alike the savage and the *savant*, and hence have been carefully observed in every age of human history. The life of the remote past, however, is preserved only in scanty records, buried in the earth, and therefore readily escapes attention. For these reasons, the study of ancient life is one of the latest of modern sciences, and among the most difficult. In view of the great advances which this department of knowledge has made within the last decade, especially in this country, I have thought it fitting to the present occasion to review briefly its development, and have chosen for my subject this evening "The History and Methods of Paleontological Discovery."

In the short time now at my command, I can only attempt to present a rapid sketch of the principal steps in the progress of this science. The literature of the subject, especially in connection with the discussions it provoked, is voluminous, and an outline of the history itself must suffice for my present purpose.

In looking over the records of paleontology, its history may conveniently be divided into four periods, well marked by prominent features, but, like all stages of intellectual growth, without definite boundaries.

The first period, dating back to the time when men first noticed fossil remains in the rocks, and queried as to their nature, is of special historic interest. The most prominent characteristic of this period was, a long and bitter contest as to the *nature of fossil remains*. Were they mere "sports of Nature," or had they once been endowed with life? Simple as this problem now seems, centuries passed before the wise men of that time were agreed upon its solution.

Sea-shells in the solid rock on the tops of mountains early attracted the attention of the ancients, and the learned men among them seem to have appreciated in some instances their true character, and given rational explanations of their presence.

The philosopher Zenophanes, of Colophon, who lived about 500 B. C., mentions the remains of fishes and other animals in the stone-quarries near Syracuse, the impression of an anchovy in the rock of Paros, and various marine fossils at other places. His conclusion from these facts was, that the surface of the earth had once been in a soft condition at the bottom of the sea; and thus the objects mentioned were entombed. Herodotus, half a century later, speaks of marine shells on the hills of Egypt and over the Libyan Desert, and he inferred therefrom that the sea had once covered that whole region. Empedocles, of Agrigentum (450 B. C.), believed that the many hippopotamus-bones found in Sicily were remains of human giants, in comparison with which the present race were as children. Here, he thought, was a battle-field between the gods and the Titans, and the bones belonged to the slain. Pythagoras (582 B. C.) had already anticipated one conclusion of modern geology, if the following statement, attributed to him by Ovid, was his own : *

> "Vidi ego quod fuerat solidissima tellus,
> Esse fretum : vidi factas ex æquore terras ;
> Et procul a pelago conchæ jacuere marinæ."

Aristotle (384–322 B. C.) was not only aware of the existence of fossils in the rocks, but has also placed on record sagacious views as to the changes in the earth's surface necessary to account for them. In the second book of his "Meteorics," he says : "The changes of the earth are so slow in comparison to the duration of our lives, that they are overlooked ; and the migrations of people after great catastrophes and their removal to other regions, cause the event to be forgotten." Again, in the same work, he says : "As time never fails, and the universe is eternal, neither the Tanais nor the Nile can have flowed for ever. The places where they rise were once dry, and there is a limit to their operations : but there is none to time. So of all other rivers ; they spring up, and they perish ; and the sea also continually deserts some lands and invades others. The same tracts, therefore, of the earth are not, some always sea, and others always continents, but everything changes in the course of time."

Aristotle's views on the subject of spontaneous generation were less sound, and his doctrines on this subject exerted a powerful influence for the succeeding twenty centuries. In the long discussion that followed concerning the nature of fossil remains, Aristotle's views were paramount. He believed that animals could originate from moist earth or the slime of rivers, and this seemed to the people of that period a much simpler way of accounting for the remains of animals in the rocks than the marvelous changes of sea and land otherwise required to explain their presence. Aristotle's opinion was in accordance with the Biblical account of the creation of man out of the dust of the earth, and hence more readily obtained credence.

Theophrastus, a pupil of Aristotle, alludes to fossil fishes found near Heraclea, in Pontus, and in Paphlagonia, and says, "They were either developed from fish-spawn left behind in the earth, or gone astray from rivers or the sea into cavities of the earth, where they had become petrified." In treating of fossil ivory and bones, the same writer supposed them to be produced by a certain plastic virtue latent

* "Metamorphoses," liber xv., 262.

in the earth. To this same cause, as we shall see, many later authors attributed the origin of all fossil remains.

Previous to this, Anaximander, the Miletian philosopher, who was born about 610 years before Christ, had expressed essentially the same view. According to both Plutarch and Censorinus, Anaximander taught that fishes, or animals very like fishes, sprang from heated water and earth, and from these animals came the human race; a statement which can hardly be considered as anticipating the modern idea of evolution, as some authors have imagined.

The Romans added but little to the knowledge possessed by the Greeks in regard to fossil remains. Pliny (23–79 A. D.), however, seems to have examined such objects with interest, and in his renowned work on natural history gave names to several forms. He doubtless borrowed largely from Theophrastus, who wrote about three hundred years before. Among the objects named by Pliny were: "*Bucardia*, like to an ox's heart"; "*Brontia*, resembling the head of a tortoise, supposed to fall in thunderstorms"; "*Glossoptra*, similar to a human tongue, which does not grow in the earth, but falls from heaven while the moon is eclipsed"; "the *Horn of Ammon*, possessing, with a golden color, the figure of a ram's horn"; "*Ceraunia* and *Ombria*, supposed to be thunderbolts"; "*Ostracites*, resembling the oyster-shell"; "*Spongites*, having the form of sponge"; "*Phycites*, similar to sea-weed or rushes." He also mentions stones resembling the teeth of hippopotamus; and says that Theophrastus speaks of fossil ivory, both black and white, of bones born in the earth, and of stones bearing the figure of bones.

Tertullian (160 A. D.) mentions instances of the remains of sea-animals on the mountains, far from the sea, but uses them as a proof of the general deluge recorded in Scripture.

During the next thirteen or fourteen centuries, fossil remains of animals and plants seem to have attracted so little attention, that few references are made to them by the writers of this period. During these ages of darkness, all departments of knowledge suffered alike, and feeble repetitions of ideas derived from the ancients seem to have been about the only contributions of that period to natural science.

Albert the Great (1205–'80 A. D.), the most learned man of his time, mentions that a branch of a tree was found, on which was a bird's nest containing birds, the whole being solid stone. He accounted for this strange phenomenon by the *vis formativa* of Aristotle, an occult force, which, according to the prevalent notions of the time, was capable of forming most of the extraordinary objects discovered in the earth.

Alexander *ab Alexandro*, of Naples, states that he saw, in the mountains of Calabria, a considerable distance from the sea, a variegated hard marble, in which many sea-shells but little changed were heaped, forming one mass with the marble.

With the beginning of the sixteenth century, a great impetus was given to the investigation of organic fossils, especially in Italy, where this study really began. The discovery of fossil shells, which abound in this region, now attracted great attention, and a fierce discussion soon arose as to the true nature of these and other remains. The ideas of Aristotle in regard to spontaneous generation, and especially his view of the hidden forces of the earth, which he claimed had power to produce such remains, now for the first time were seriously questioned, although it was not till nearly two centuries later that these doctrines lost their dominant influence.

Leonardo da Vinci, the renowned painter and philosopher, who was born in 1452, strongly opposed the commonly accepted opinions as to the origin of organized fossils. He claimed that the fossil shells under discussion were what they seemed, and had once lived at the bottom of the sea. "You tell me," he says, "that Nature and the influence of the stars have formed these shells in the mountains; then show me a place in the mountains where the stars at the present day make shelly forms of different ages, and of different species in the same place." Again, he says, "In what manner can such a cause account for the petrifactions in the same place of various leaves, sea-weeds, and marine crabs?"

In 1517, excavations in the vicinity of Verona brought to light many curious petrifactions, which led to much speculation as to their nature and origin. Among the various authors who wrote on this subject was Fracastoro, who declared that the fossils once belonged to living animals, which had lived and multiplied where found. He ridiculed the prevailing ideas that the plastic force of the ancients could fashion stones into organic forms. Some writers claimed that these shells had been left by Noah's flood, but against this idea Fracastoro offered a mass of evidence, which would now seem conclusive, but which then only aroused bitter hostility. That inundation, he said, was too transient; it consisted mainly of fresh water; and, if it had transported shells to great distances, must have scattered them over the surface, not buried them in the interior of mountains.

Conrad Gesner (1516–'65), whose history of animals has been considered the basis of modern zoölogy, published at Zurich, in 1565, a small but important work entitled "De omni rerum fossilium genere." It contained a catalogue of the collection of fossils made by John Kentmann. This is the oldest catalogue of fossils with which I am acquainted.

George Agricola (1494–1555) was, according to Cuvier, the first mineralogist who appeared after the revival of learning in Europe.

In his great work, "De Re Metallica," published in 1546, he mentions various fossil remains, and says they were produced by a certain "*materia pinguis*," or fatty matter, set in fermentation by heat. Some years later, Bauhin published a descriptive catalogue of the fossils he had collected in the neighborhood of Boll, in Wurtemberg.*

Andrew Mattioli, a distinguished botanist, adopted Agricola's notion as to the origin of organized fossils, but admitted that shells and bones might be turned into stone by being permeated by a "lapidifying juice." Falloppio, the eminent professor of anatomy at Padua, believed that fossil shells were generated by fermentation where they were found; and that the tusks of elephants, dug up near Apulia, were merely earthy concretions. Mercati, in 1574, published figures of the fossil shells preserved in the Museum of the Vatican, but expressed the opinion that they were only stones, and owed their peculiar shapes to the heavenly bodies. Olivi, of Cremona, described the fossils in the Museum at Verona, and considered them all "sports of nature."

Palissy, a French author, in 1580, opposed these views, and is said to have been the first to assert in Paris that fossil shells and fishes had once belonged to marine animals. Fabio Colonna appears to have first pointed out that some of the fossil shells found in Italy were marine and some terrestrial.

Another peculiar theory discussed in the sixteenth century deserves mention. This was the vegetation theory, especially advocated by Tournefort and Camerarius, both eminent as botanists. These writers believed that the seeds of minerals and fossils were diffused throughout the sea and the earth, and were developed into their peculiar forms by the regular increment of their particles, similar to the formation of crystals. "How could the *Cornu Ammonis*," Tournefort asked, "which is constantly in the figure of a volute, be formed without a seed containing the same structure in the small as in the larger forms? Who molded it so artfully, and where are the molds?" The stalactites which formed in caverns in various parts of the world were also supposed to be proofs of this vegetative growth.

Still another theory has been held at various times, and is not yet entirely forgotten, namely: that the Creator made fossil animals and plants just as they are found in the rocks, in pursuance of a plan beyond our comprehension. This theory has never prevailed among those familiar with scientific facts, and hence needs here no further consideration.

An interest in fossil remains arose in England later than on the Continent; but when attention was directed to them, the first opinions as to their origin were not less fanciful and erroneous than those to which we have already referred. Dr. Plot, in his "Natural History of Oxfordshire," published in 1677, considered the origin of fossil

* "Historia novi et admirabilis Fontis Balneique Bollensis, in Ducatu Wirtembergico." Montbéliard, 1598.

shells and fishes to be due to a "plastic virtue, latent in the earth," as Theophrastus had suggested long before. Lhwyd, in his "Lithophylacii Britannici Ichnographia," published in Oxford in 1699, gives a catalogue of English fossils contained in the Ashmolean Museum. He opposed the *vis plastica* theory, and expressed the opinion that the spawn of fishes and other marine animals had been raised with the vapors from the sea, conveyed inland by clouds, and deposited by rain, had permeated into the interior of the earth, and thus produced the fossil remains we find in the rocks. About this time several important works were published in England by Dr. Martin Lister, which did much to diffuse a true knowledge of fossil remains. He gave figures of recent shells side by side with some of the fossil forms, so that the resemblance became at once apparent. The fossil species of shells he called "turbinated and bivalve stones," and adds, "either these were terriginous, or, if otherwise, the animals which they so exactly represent have become extinct."

During the seventeenth century there was a considerable advance in the study of fossil remains. The discussions in regard to the nature and origin of these objects had called attention to them, and many collections were now made, especially in Italy, and also in Germany, where a strong interest in this subject had been aroused. Catalogues of these collections were not unfrequently published, and some of them were illustrated with such accurate figures, that many of the species can now be readily recognized. In this century, too, an important step in advance was made by the collection and description of fossils from particular localities and regions, in distinction from general collections of curiosities.

Casper Schwenkfeld, in 1600, published a catalogue of the fossils discovered in Silesia; in 1622 a detailed description of the renowned Museum of Calceolarius, of Verona, appeared; and in 1642 a catalogue of Besler's collection. Wormius's catalogue was published in 1652, Spener's in 1663, and Septala's in 1666. A description of the Museum of the King of Denmark was issued in 1669, Cottorp's catalogue in 1674, and that of the renowned Kirscher in 1678. Dr. Grew gave an account in 1687 of the specimens in the Museum of Gresham's College in England; and in 1695 Petiver, of London, published a catalogue of his very extensive collection. A catalogue by Fred. Lauchmund, on the fossils of Hildesheim, appeared in 1669, and the fossils of Switzerland were described by John Jacob Wagner in 1689. Among similar works were the dissertations of Gyer, at Frankfort, and Albertus, at Leipsic.

Steno, a Dane, who had been Professor of Anatomy at Padua, published in 1669 one of the most important works of this period.* He entered earnestly into the controversy as to the origin of fossil re-

* "De solido intra solidum naturaliter contento."

mains, and by dissecting a shark from the Mediterranean, proved that its teeth were identical with some found fossil in Tuscany. He also compared the fossil shells found in Italy with existing species, and pointed out their resemblance. In the same work, Steno expressed some very important views in regard to the different kinds of strata, and their origin, and first placed on record the important fact that the oldest rocks contain no fossils.

Scilla, the Sicilian painter, published in 1670 a work on the fossils of Calabria, well illustrated. He is very severe against those who doubted the organic origin of fossils, but is inclined to consider them relics of the Mosaic deluge.

Another instance of the power of the *lusus naturæ* theory, even at the close of the seventeenth century, deserves mention. In the year 1696 the skeleton of a fossil elephant was dug up at Tonna, near Gotha, in Germany, and was described by William Ernest Tentzel, a teacher in the Gotha Gymnasium. He declared the bones to be the remains of an animal that had lived long before. The medical faculty in Gotha, however, considered the subject, and decided officially that this specimen was only a freak of Nature.

Besides the authors I have mentioned, there were many others who wrote about fossil remains before the close of the seventeenth century, and took part in the general discussion as to their nature and origin. During the progress of this controversy the most fantastic theories were broached and stoutly defended, and, although refuted from time to time by a few clear-headed men, continually sprang up anew, in the same or modified forms. The influence of Aristotle's views of equivocal generation, and especially the scholastic tendency to disputation, so prevalent during the middle ages, had contributed largely to the retardation of progress, and yet a real advance in knowledge had been made. The long contest in regard to the nature of fossil remains was essentially over, for the more intelligent opinion at the time now acknowledged that these objects were not mere "sports of Nature," but had once been endowed with life. At this point, therefore, the first period in the history of paleontology, as I have indicated it, may appropriately end.

It is true that, later still, the old exploded errors about the plastic force and fermentation were from time to time revived, as they have been almost to the present day; but learned men, with few exceptions, no longer seriously questioned that fossils were real organisms, as the ancients had once believed. The many collections of fossils that had been brought together, and the illustrated works that had been published about them, were a foundation for greater progress, and, with the eighteenth century, the second period in the history of paleontology began.

The main characteristic of this period was the general belief that *fossil remains were deposited by the Mosaic deluge.* We have seen that this view had already been advanced, but it was not till the beginning of the eighteenth century that it became the prevailing view. This doctrine was strongly opposed by some courageous men, and the discussion on the subject soon became even more bitter than the previous one, as to the nature of fossils.

In this diluvial discussion theologians and laymen alike took part. For nearly a century the former had it all their own way, for the general public, then as now, believed what they were taught. Noah's flood was thought to have been universal, and was the only general catastrophe of which the people of that day had any knowledge or conception.

The scholars among them were of course familiar with the accounts of Deucalion and his ark, in a previous deluge, as we are to-day with similar traditions held by various races of men. The firm belief that the earth and all it contains was created in six days; that all life on the globe was destroyed by the deluge, except alone what Noah saved; and that the earth and its inhabitants were to be destroyed by fire, was the foundation on which all knowledge of the earth was based. With such fixed opinions, the fossil remains of animals and plants were naturally regarded as relics left by the flood described in Holy Writ. The dominant nature of this belief is seen in nearly all the literature in regard to fossils published at this time, and some of the works which then appeared have become famous on this account.

In 1710 David Büttner published a volume entitled "Rudera Diluvii Testes." He strongly opposed Lhwyd's explanation of the origin of fossils, and referred these objects directly to the flood. The most renowned work, however, of this time, was published at Zurich in 1726, by Scheuchzer, a physician and naturalist, and professor in the University of Altorf. It bore the title "Homo Diluvii Testis." The specimen upon which this work was based was found at Oeningen, and was regarded as the skeleton of a child destroyed by the deluge. The author recognized in this remarkable fossil, not merely the skeleton, but also portions of the muscles, the liver, and the brain. The same author was fortunate enough to discover, subsequently, near Altorf, two fossil vertebræ, which he at once referred to that "accursed race destroyed by the flood!" These, also, he carefully described and figured in his "Physica Sacra," published at Ulm in 1731. Engravings of both were subsequently given in the "Copper-Bible." Cuvier afterward examined these interesting relics, and pronounced the skeleton of the supposed child to be the remains of a gigantic salamander, and the two vertebræ to be those of an ichthyosaurus!

Another famous book appeared in Germany in the same year in which Scheuchzer's first volume was published. The author was John Bartholomew Adam Beringer, professor at the University of Würzburg, and his great work* indirectly had an important influence upon the investigation of fossil remains. The history of the work is instructive, if only as an indication of the state of knowledge at that date. Professor Beringer, in accordance with views of his time, had taught his pupils that fossil remains, or "figured stones," as they were called, were mere "sports of Nature." Some of his fun-loving students reasoned among themselves, "If Nature can make figured stones in sport, why can not we?" Accordingly, from the soft limestone in the neighboring hills, they carved out figures of marvelous and fantastic forms, and buried them at the localities where the learned Professor was accustomed to dig for his fossil treasures. His delight at the discovery of these strange forms encouraged further production, and taxed the ingenuity of these youthful imitators of Nature's secret processes. At last Beringer had a large and unique collection of forms, new to him and to science, which he determined to publish to the world. After long and patient study his work appeared, in Latin, dedicated to the reigning prince of the country, and illustrated with twenty-one folio plates. Soon after the book was published the deception practiced upon the credulous Professor became known; and, in place of the glory he expected from his great undertaking, he received only ridicule and disgrace. He at once endeavored to repurchase and destroy the volumes already issued, and succeeded so far that few copies of the first edition remain. His small fortune, which had been seriously impaired in bringing out his grand work, was exhausted in the effort to regain what was already issued, as the price rapidly advanced in proportion as fewer copies remained; and, mortified at the failure of his life's work, he died in poverty. It is said that some of his family, dissatisfied with the misfortune brought upon them by this disgrace and the loss of their patrimony, used a remaining copy for the production of a second edition, which met with a large sale, sufficient to repair the previous loss and restore the family fortune. This work of Beringer, in the end, exerted an excellent influence upon the dawning science of fossil remains. Observers became more cautious in announcing supposed discoveries, and careful study of natural objects gradually replaced vague hypotheses.

The above works, however, are hardly fair examples of the literature on fossils during this part of the eighteenth century. Scheuchzer had previously published his well-known "Complaint and Vindication of the Fishes," illustrated with good plates. Moro, in his work on "Marine Bodies which are found in the Mountains," 1740, showed the effects of volcanic action in elevating strata, and causing faults. Vallisneri had studied with care the marine deposits of Italy. Donati, in 1750, had investigated the Adriatic, and ascertained by soundings

* "Lithographia Wirceburgensis, ducentis lapidum figuratorum, a potiori, insectiformium, prodigiosis imaginibus exornata." Wirceburgi, 1726. Edit. II. Francofurti et Lipsiæ, 1767.

that shells and corals were being imbedded in the deposits there, just as they were found in the rocks.

John Gesner's dissertation, "De Petrificatis," published at Leyden in 1758, was a valuable contribution to the science. He enumerated the various kinds of fossils, and the different conditions in which they are found petrified, and stated that some of them, like those at Oeningen, resembled the shells, fishes, and plants of the neighboring region, while others, such as Ammonites and Belemnites, were either unknown species, or those found only in distant seas. He discusses the structure of the earth at length, and speculates as to the causes of changes in sea and land. He estimates that, at the observed rate of recession of the ocean, to allow the Apennines, whose summits are filled with marine shells, to reach their present height, would have taken about eighty thousand years, a period more than "ten times greater than the age of the universe." He accordingly refers the change to the direct command of the Deity, as related by Moses, that "the waters should be gathered together in one place, and the dry land appear."

Voltaire (1694–1778) discussed geological questions and the nature of fossils in several of his works, but his published opinions are far from consistent. He ridiculed effectively and justly the cosmogonists of his day, and showed also that he knew the true nature of organic remains. Finding, however, that theologians used these objects to confirm the Scriptural account of the deluge, he changed his views, and accounted for fossil shells found in the Alps by suggesting that they were Eastern species, dropped by the pilgrims on their return from the Holy Land!

Buffon, in 1749, published his important work on natural history, and included in it his "Theory of the Earth," in which he discussed, with much ability, many points in geology. Soon after the book was published, he received an official letter from the Faculty of Theology in Paris, stating that fourteen propositions in his works were reprehensible, and contrary to the creed of the Church. The first objectionable proposition was as follows: "The waters of the sea have produced the mountains and valleys of the land; the waters of the heavens, reducing all to a level, will at last deliver the whole land over to the sea; and the sea, successively prevailing over the land, will leave dry new continents like those we inhabit."

Buffon was politely requested by the college to recant, and, having no particular desire to be a martyr to science, submitted the following declaration, which he was required to publish in his next work: "I declare that I had no intention to contradict the text of Scripture; that I believe most firmly all therein related about the creation, both as to order of time and matter of fact; and I abandon everything in my book respecting the formation of the earth, and, generally, all which may be contrary to the narration of Moses."

This single instance will suffice to indicate one great obstacle to the advancement of science, even up to the middle of the eighteenth century.

Another important work appeared in France about this time, Bourguet's "Traité des Pétrifactions," published in 1758, which is well illustrated with faithful plates. In England, a discourse on earthquakes, by Dr. Robert Hooke, was published in 1705. This author held some views in advance of his time, and maintained that figured stones were "really the several bodies they represent or the moldings of them petrified, and not, as some have imagined, a *lusus naturæ*, sporting herself in the needless formation of useless things." He anticipates one important conclusion from fossils, when he states that "though it must be very difficult to read them and to raise a chronology out of them, and to state the intervals of time wherein such or such catastrophes and mutations have happened, yet it is not impossible." He also states that fossil turtles, and such large Ammonites as are found in Portland, seem to have been the productions of hotter countries, and hence it is necessary to suppose that England once lay under the sea within the torrid zone. He seems to have suspected that some of the fossils of England belonged to extinct species, but thought they might possibly be found living in the bottom of distant oceans.

Dr. Woodward's "Natural History of the Fossils of England" appeared in 1729. This work was based on a systematic collection of fossils which he had brought together, and which he subsequently bequeathed to the University of Cambridge, where it is still preserved, with his arrangement carefully retained. The descriptive part of this work is interesting, but his conclusions are made to coincide strictly with the Scriptural account of the creation and deluge. He had previously stated, in another work, that he believed "the whole terrestrial globe to have been taken to pieces and dissolved at the flood, and the strata to have settled down from this promiscuous mass." In support of this view, he stated that "marine bodies are lodged in the strata according to the order of their gravity, the heavier shells in stones, the lighter in chalk, and so of the rest." *

The most important work on fossils published in Germany at this time was that of George Wolfgang Knorr, which was continued after his death by Walch. This work consisted of four folio volumes, with many plates, and was printed at Nuremberg, 1755–'73. A large number of fossils were accurately figured and described, and the work is one of permanent value.† A French translation of this work appeared in 1767–'78. Burton's "Oryctographie de Bruxelles," 1784, contains figures and descriptions of fossils found in Belgium.

Abraham Gottlieb Werner (1750–1817), Professor of Mineralogy

* "Essay toward a Natural History of the Earth," 1695.

† "Lapides ex celeberr. viror. sententia diluvii universalis testes, quos in ordines ac species distribuit, suis coloribus expremit," etc. 272 Tab. 1755–'73.

at Freyberg, did much to advance the science of geology, and indirectly that of fossils. He first indicated the relations of the main formations to each other, and, according to his pupil, Professor Jameson, first made the highly important observation that "different formations can be discriminated by the petrifactions they contain." Moreover, that "the petrifactions contained in the oldest rocks are very different from any of the species of the present time; that the newer the formation, the more do the remains approach in form to the organic beings of the present creation." Unfortunately, Werner published little, and his doctrines were mainly disseminated by his enthusiastic pupils.

The great contest between the Vulcanists and the Neptunists started at this time, mainly through Werner, whose doctrines led to the controversy. The comparative merits of fire and water, as agencies in the formation of certain rocks, were discussed with a heat and acrimony characteristic of the subject and the time. Werner believed in the aqueous theory, while the igneous theory was especially advocated by Hutton, of Edinburgh, and his illustrator, Playfair. This discussion resulted in the advancement of descriptive geology, but the study of fossils gained little thereby.

The "Protogæa" of Leibnitz, the great mathematician, published in 1749, about thirty years after his death, was a work of much merit. This author supposed that the earth had gradually cooled from a state of igneous fusion, and was subsequently covered with water. The subsidence of the lower part of the earth, the deposits of sedimentary strata from inundations, and their induration, as well as other changes, followed. All this he supposed to have been accomplished in a period of six natural days. In the same work Leibnitz shows that he had examined fossils with considerable care.

Linnæus (1707–1778), the famous Swedish botanist, and the founder of the modern system of nomenclature in natural history, confined his attention almost entirely to the living forms. Although he was familiar with the literature of fossil remains, and had collected them himself, he did not include them in his system of plants and animals, but kept them separate, with the minerals; hence he did little directly to advance this branch of science.

During the last quarter of the eighteenth century, the belief that fossil remains were deposited by the deluge sensibly declined, and the dawn of a new era gradually appeared. Let us pause for a moment here, and see what real progress had been made—what foundation had been laid on which to establish a science of fossil remains.

The true nature of these objects had now been clearly determined. They were the remains of animals and plants. Most of them certainly were not the relics of the Mosaic deluge, but had been deposited long before, part in fresh water and part in the sea. Some indicated a mild climate, and some the tropics. That any of these were extinct species was as yet only suspected. Large collections of fossils had now been made, and valuable catalogues, well illustrated, had been published. Something was known, too, of the geological position of fossils. Steno, long before, had observed that the lowest rocks were without life. Lehmann had shown that above these primitive rocks, and derived from them, were the secondary strata, full of the records of life; and above these were alluvial deposits, which he referred to local floods, and the deluge of Noah. Rouelle, Fuchsel, and Odoardi had shed new light on this subject. Werner had distinguished the transition rocks containing fossil remains, between the primitive and the secondary, while everything above the chalk he grouped together, as the "overflowed land." Werner, as we have seen, had done more than this, if we give him the credit his pupils claim for him. He had found that the formations he examined contained each its own peculiar fossils, and that from the older to the newer there was a gradual approach to recent forms. William Smith had worked out the same thing in England, and should equally divide the honor of this important discovery.

The greatest advance, however, up to this time, was that men now preferred to *observe* rather than to *believe*, and facts were held in greater esteem than vague speculations. With this preparation for future progress, the second period in the history of paleontology, as I have divided it, may appropriately be considered at an end.

Thus far, I have said nothing in regard to one branch of my subject, the *methods* of paleontological research, for, up to this time, of method there was none. We have seen that those of the ancients who noticed marine shells in the solid rock called them such, and concluded that they had been left there by the sea. The discovery of fossils led directly to theories of how the earth was formed. Here the progress was slow. Subterranean spirits were supposed to guard faithfully the mysteries of the earth; while above the earth, Authority guarded with still greater power the secrets men in advance of their age sought to know. The dominant idea of the first sixteen centuries of the present era was, that the universe was made for man. This was the great obstacle to the correct determination of the position of the earth in the universe, and, later, of the age of the earth. The contest of astronomy against authority was long and severe, but the victory was at last with science. The contest of geology against the same power followed, and continued almost to our day. The result is still the same. In the early stages of this contest there was no strife, for science was benumbed by the embrace of superstition and creed, and little could be done till that was cast off. In a superstitious age, when every natural event is referred to a supernatural cause, science can not live; and often as the sacred fire may be kindled by courageous, far-seeing souls, will it be quenched by the dense mists of ignorance around it. Scarcely less fatal to the growth of science is the age of Authority, as the past proves too well. With freedom of thought came definite knowledge and certain progress; but two thousand years was long to wait.

With the opening of the present century began a new era in paleontology, which we may here distinguish as the third period in its history. This branch of knowledge became now a science. Method replaced disorder, and systematic study superseded casual observation. For the next half century the advance was continuous and rapid. One characteristic of this period was, *the accurate determination of fossils by comparison with living forms.* This will separate it from the two former epochs. Another distinctive feature of this period was the general belief that *every species, recent and extinct, was a separate creation.*

At the very beginning of the epoch we are now to consider, three names stand out in bold relief—Cuvier, Lamarck, and William Smith. To these men the science of paleontology owes its origin. Cuvier and Lamarck, in France, had all the power which great talent, education, and station could give; William Smith, an English surveyor, was without culture or influence. The last years of the eighteenth century had been spent by each of these men in preparation for his chosen work, and the results were now given to the world. Cuvier laid the foundation of the paleontology of vertebrate animals; Lamarck, of the invertebrates; and Smith established the principles of stratigraphical paleontology. The investigator of fossils to-day seldom needs to consult earlier authors of the science.

George Cuvier (1769–1832), the most famous naturalist of his time, was led to the study of extinct animals by ascertaining that the remains of fossil elephants which he examined were extinct species. "This idea," he says later, "which I announced to the Institute in the month of January, 1796, opened to me views entirely new respecting the theory of the earth, and determined me to devote myself to the long researches and to the assiduous labors which have now occupied me for twenty-five years." *

It is interesting to note here that in this first investigation of fossil vertebrates, Cuvier employed the same method that gave him such important results in his later researches. Remains of elephants had been known to Europe for centuries, and many authors, from Pliny down to the contemporaries of Cuvier, had written about them. Some had regarded the bones as those of human giants, and those who recognized what they were considered them remains of the elephants imported by Hannibal or the Romans. Cuvier, however, compared the fossils directly with the bones of existing elephants, and proved them

* "Ossemens Fossiles," second edition, vol. i., p. 178.

to be distinct. The fact that these remains belong to extinct species was of great importance. In the case of fossil shells, it was difficult to say that any particular form was not living in a distant ocean; but the two species of existing elephants, the Indian and the African, were well known, and there was hardly a possibility that another living one would be found.

It is important to bear in mind, too, that Cuvier's preparation for the study of the remains of animals was far in advance of any of his predecessors. He had devoted himself for years to careful dissections in the various classes of the animal kingdom, and was really the founder of comparative anatomy, as we now understand it. Cuvier investigated the different groups of the whole kingdom with care, and proposed a new classification, founded on the plan of structure, which in its main features is the one in use to-day. The first volume of his "Comparative Anatomy" appeared in 1800, and the work was completed in five volumes in 1805.

Previous to Cuvier, the only general catalogue of animals was contained in Linnæus's "Systema Naturæ." In this work, as we have seen, fossil remains were placed with the minerals, not in their appropriate places among the animals and plants. Cuvier enriched the animal kingdom by the introduction of fossil forms among the living, bringing all together into one comprehensive system. His great work, "Le Règne Animal," appeared in four volumes in 1817, and with its two subsequent editions remains the foundation of modern zoölogy. Cuvier's classic work on vertebrate fossils—"Recherches sur les Ossemens Fossiles," in four volumes, appeared in 1812–'13. Of this work it is but just to say that it could only have been written by a man of genius, profound knowledge, the greatest industry, and with the most favorable opportunities.

The introduction to this work was the famous "Discourse on the Revolutions of the Surface of the Globe," which has perhaps been as widely read as any other scientific essay. The discovery of fossil bones in the gypsum-quarries of Paris by the workmen, who considered them human remains; the careful study of these relics by Cuvier, and his restorations from them of strange beasts that had lived long before, is a story with which you are all familiar. Cuvier was the first to prove that the earth had been inhabited by a succession of different series of animals, and he believed that those of each period were peculiar to the age in which they lived.

In looking over his work after a lapse of three quarters of a century, we can now see that Cuvier was wrong on some important points, and failed to realize the direction in which science was rapidly tending. With all his knowledge of the earth, he could not free himself from tradition, and believed in the universality and power of the Mosaic deluge. Again, he refused to admit the evidence brought forward by his distinguished colleagues against the permanence of species, and used all his great influence to crush out the doctrine of evolution, then first proposed. Cuvier's definition of a species, the dominant one for half a century, was as follows: "A species comprehends all the individuals which descend from each other, or from a common parentage, and those which resemble them as much as they do each other."

The law of "Correlation of Structures," as laid down by Cuvier, has been more widely accepted than almost anything else that bears his name; and yet, although founded in truth, and useful within certain limits, it would certainly lead to serious error if applied widely in the way he proposed.

In his discourse he sums up this law as follows: "A claw, a shoulder-blade, a condyle, a leg or arm bone, or any other bone separately considered, enables us to discover the description of teeth to which they have belonged; so also reciprocally we may determine the form of the other bones from the teeth. Thus, commencing our investigation by a careful survey of any one bone by itself, a person who is sufficiently master of the laws of organic structure may, as it were, reconstruct the whole animal to which that bone had belonged."

We know to-day that unknown extinct animals can not be restored from a single tooth or claw, unless they are very similar to forms already known. Had Cuvier himself applied his methods to many forms from the early Tertiary or older formations, he would have failed. If, for instance, he had had before him the disconnected fragments of an Eocene Tillodont, he would undoubtedly have referred a molar tooth to one of his pachyderms; an incisor tooth to a rodent; and a claw-bone to a carnivore. The tooth of a Hesperornis would have given him no possible hint of the rest of the skeleton, nor its swimming feet the slightest clew to the ostrich-like sternum or skull. And yet the earnest belief in his own methods led Cuvier to some of his most important discoveries.

Jean Lamarck (1744–1829), the philosopher and naturalist, a colleague of Cuvier, was a learned botanist before he became a zoölogist. His researches on the invertebrate fossils of the Paris Basin, although less striking, were not less important than those of Cuvier on the vertebrates; while the conclusions he derived from them form the basis of modern biology. Lamarck's method of investigation was the same essentially as that used by Cuvier, namely, a direct comparison of fossils with living forms. In this way he soon ascertained that the fossil shells imbedded in the strata beneath Paris were many of them extinct species, and those of different strata differed from each other. His first memoir on this subject appeared in 1802,* and, with his later works, effected a revolution in conchology. His "System of Invertebrate Animals" appeared the year before, and his famous "Philosophie Zoölogique" in 1809. In these two works, Lamarck first announced

* "Mémoires sur les Fossiles des Environs de Paris," 1802–'6.

the principles of evolution. In the first volume of his "Natural History of Invertebrate Animals" * he gave his theory in detail; and to-day one can only read with astonishment his far-reaching anticipations of modern science. These views were strongly supported by Geoffroy Saint-Hilaire, but bitterly opposed by Cuvier; and their great contest on this subject is well known.

In looking back from this point of view, the philosophical breadth of Lamarck's conclusions, in comparison with those of Cuvier, is clearly evident. The invertebrates on which Lamarck worked offered less striking evidence of change than the various animals investigated by Cuvier; yet they led Lamarck directly to evolution, while Cuvier ignored what was before him on this point, and rejected the proof offered by others. Both pursued the same methods, and had an abundance of material on which to work, yet the facts observed induced Cuvier to believe in catastrophes, and Lamarck in the uniform course of nature. Cuvier declared species to be permanent, Lamarck that they were descended from others. Both men stand in the first rank in science, but Lamarck was the prophetic genius half a century in advance of his time.

[*To be continued.*]

THE BEGINNINGS OF GEOGRAPHICAL SCIENCE.

BY GEORGE A. JACKSON.

NO other science has to-day so distinguished a patronage as that of geography. In September, 1877, there convened at Brussels, in a palace of the King of the Belgians, and at his invitation, a Congress made up of the presidents of the leading geographical societies, and the most distinguished geographical writers, and explorers, and patrons of explorations, in the world. At that Congress was formed an association, under the presidency of King Leopold II., which has for its object the exploring, and opening up to science and civilization, of the whole unknown territory of Central Africa. Branches of this organization are formed in nearly all the nations of Europe, and are, as a rule, under the direction of the royal houses. Mr. Stanley also, in his "Dark Continent," makes hearty acknowledgment of encouragements and rewards received at royal hands. And as in these last days, so in the first days of its history, royal patronage did much to promote geographical science. The very earliest knowledge of geography was doubtless gained in a blind way, as men went to neighboring countries in the pursuit of trade; but Herodotus tells us that so far back as 640

* "Histoire naturelle des Animaux sans Vertèbres," 7 vols., Paris, 1815–1822. Second edition, 11 vols., 1835–1845.

B. C. a voyage for geographical discovery was undertaken, under the patronage of a king, Pharaoh Necho of Egypt. This monarch engaged a company of Tyrians to circumnavigate Africa. Setting out by the Red Sea, these voyagers sailed southward until autumn, when they landed and sowed corn, and waited for it to ripen. Reaping their crop, they set sail again, and in this manner, having consumed two years, in the third year they turned the pillars of Hercules and came back to Egypt. They asserted, said Herodotus, that which he could not believe, though others might, that, in sailing around Libya, they had the sun on the right hand. The arguments for and against the actuality of this voyage need not here be given. Suffice it that it was not an impossible achievement for mariners of that age; and that Eratosthenes, one of the earliest geographers, represented Libya as circumnavigable.

Accustomed as we are to-day to think of all science as of modern development, most men are content to have read a summary of the "Erdkunde," to have followed Humboldt in his principal researches, and to have formed some acquaintance with Buffon, and Zimmermann, and Blumenbach. If, besides, they know something of Malte-Brun, they think they have compassed the history of the science. A hundred years ago there was no such feeling. The vast advances of this century had not been made. Scholars were not far enough removed from the Renaissance to have lost all reverence for the ancients; and, although they no longer turned to Ptolemy for information, they had a lingering affection for the work which had been the geographical authority down to two hundred years before their day. Elaborate works were written in exposition of the ancient systems, with a patience that would hardly be exercised to-day. The father of such study was D'Anville; but perhaps no single work upon the subject is of more value to us than that of M. Gosselin.* In our sketch we have made large use of this work.

Tradition takes us back to days when men thought of the earth as a flat disk, covered with the arching vault of the skies, whose edges rested upon far-off giant pillars; and even to the time when they believed that the earth rested upon elephants, who stood on the back of a tortoise, who in turn were encompassed in the folds of a serpent; but those were not the days of science. The first among the Greeks to teach the doctrine of the sphericity of the earth was Thales (B. C. 640). He held that the equator was cut obliquely by the ecliptic, and he divided the earth into five zones. His successor was Anaximander, who also taught that the earth was a sphere (Diogenes Laertius), though some said (Plutarch) that he called it a column. The latter statement could hardly be true, as he was sufficiently scientific to erect at Lacedæmon a gnomon for observing the solstices and equinoxes.

* Géographie des Grecs Analysée; ou Les Systêmes d'Eratosthenes, de Strabon, et de Ptolémée comparée entre eux et avec nos Connoissances modernes. M. Gosselin, à Paris, MDCCLXXXX.

He is even said to have been the inventor of this instrument—which was a simple column, the length of whose shadow determined the position of the sun—though more probably Thales had brought the knowledge of it from Egypt. To Anaximander is also assigned the honor of having made the first geographical chart known among the Greeks. He is even claimed to have made an artificial globe representing the earth, with divisions of land and water. He was not, however, the inventor of maps, since among the Egyptians Sesostris, long before his day, is said to have caused maps to be made. Passing over Anaximenes and Anaxagoras, the next name worthy of mention is that of Pythagoras (B. C. 570), who, like Thales, had traveled in Egypt, where he is said to have learned the obliquity of the ecliptic. But the great thing for which Pythagoras is remembered by scientists was his doctrine that the earth revolved about the sun—a truth, however, which he taught only esoterically, his open doctrine being the common one that the sun revolved about the earth. Herodotus (B. C. 484), notwithstanding his extensive travels, contributed nothing to mathematical geography, and had very incorrect ideas as to the several divisions of the world. "Europe," he said, "was as long as Asia and Africa together. The river Nile, before entering Egypt, flowed eastward from near the west coast of Africa." This opinion he formed partly from the account which he said had been given by certain youths who were taken prisoners and carried into the interior of Africa, to a city on the bank of a great river flowing eastward, in which were crocodiles. Another reason he had was that to the north of the Mediterranean Sea a great river, the Ister (Danube) was known to flow from the extreme west to the east of Europe; and so, "*inferring the unknown from the known*," he concluded that the Nile must flow through Africa in a similar way.

Of more value to science were the observations of Pytheas (about 320 B. C.), a Greek seaman of Massilia (Marseilles), who sailed far northward from the coasts of Britain, where he said the longest day was nineteen hours long, to what he called Thule (probably Iceland), where he said "the summer tropic served for the arctic circle." Notwithstanding certain wild statements of Pytheas, such as that at this place there was found neither earth, air, nor sea, but a mingling of them all; and that the days and nights there were six months in length, we can not help believing that he did reach the arctic circle, and observe the phenomenon of the sun remaining above the horizon throughout the twenty-four hours. To Pytheas also is due the first suggestion of a computation of latitude. He recorded that the length of the gnomon at Marseilles, the day of the summer solstice, was to the length of the shadow as 120 to 41·8, which, reckoning the tropic at 23° 51′ 15″, where it was placed by Eratosthenes, would give a latitude of 43° 3′ 35″. If allowance be made for the penumbra, this reckoning will be found very nearly correct. Other names to be noticed are Eudemus, the first Greek to give the angle of the ecliptic—as subtended by the side of a pentadecagon, or equal to 24°—and Eudoxus, who wrote a work on the "Period or Circumference of the Earth."

This brings us down to the school of Alexandria. Alexander had founded near the Canopic mouth of the Nile a city which was destined long to perpetuate his name and glory. The glory was to come not so much from its commercial importance, though it rose to be the chief commercial city of the world, as from its intellectual supremacy. It was the ambition of the Ptolemies to make their capital the intellectual center of the world, and in this they were successful. The Attic and Ionian scholars gave place to the Alexandrian, not only in the department of letters, but also in the domain of science. One of the librarians of the great Alexandrian Library was Eratosthenes (B. C. 270), who may justly be called the Father of Geography. His work is in great part preserved to us in the pages of Strabo and Pliny. Having under his eye everything that had ever been written upon the subject, he first combined the whole into a complete system, which can to-day be restored. The map of the world which he prepared, if less perfect in some respects than Ptolemy's, was in other respects far more perfect; indeed, was the most correct which the world was to see down to the sixteenth century A. D. Besides other and doubtless very important data, of which we have no information, Eratosthenes must have had a record of an expedition undertaken in the fifth century B. C. by Hanno, under the direction of the Carthaginian Senate, in which he sailed down the west coast of Africa as far as to the Gulf of Benin; as well as an account of the observations made by the followers of Alexander during his march through Asia, and by his naval commander Nearchus, who conducted the fleet from the mouths of the Indus along the coast to the Euphrates.

After him came Hipparchus, who lived at Rhodes (B. C. 160–145). His great merit was in his use of astronomical observations to determine positions upon the earth, instead of depending upon itinerary distances from a few known points, as had been the method of Eratosthenes. But the age did not appreciate his work, and the science was not to realize the advance which was thus made possible; nearly three centuries must elapse before the fruit of his labors was to appear. Eratosthenes had been able to determine latitude by the heavenly bodies, but not longitude. Hipparchus showed how this also could be done, by observing the eclipses of the sun and moon. Again, he invented the method of projection in map-making, another most valuable contribution to the science which was to be despised until a coming age.

Posidonius is a name to be remembered for an error which he introduced into the science, so successfully that it remained for many centuries. What it was we shall see under Ptolemy.

Strabo (54 B. C.), notwithstanding his voluminous work on geography, which, indeed, is of great value as a compilation of the facts then known about the different countries of the world, was not, like Eratosthenes, Hipparchus, and Ptolemy, a scientific geographer. He neglected mathematical and astronomical data, and, instead of following Hipparchus's method of projection, of which he knew, he expressly says that he describes the world as if it were spread out as a vast plain. Indeed, there is some reason to think that Strabo did not even prepare a map to accompany his work. From his descriptions, however, a map may be made, as was done by both D'Anville and Gosselin, and we find that it does not differ greatly from that of Eratosthenes. Almost the only improvements are in a better outline of the coasts of Iberia and Gaul, in a truer longitude for the Sicilian Straits, and in a correct distance from these straits to Rhodes. On the other hand, Strabo loses sight of Thule, says that Africa is not circumnavigable, and makes greater errors in latitude and longitude than his distinguished predecessor.

The leading Roman writers on geography were Pomponius Mela, who wrote a treatise in three books, and Pliny, who devoted a part of his great work on natural history to geography.

Marin of Tyre deserves a glance. Phœnicia was the great commercial nation of the earlier ages. Her mariners brought tin from Britain and spices from the far East. She certainly had opportunities to surpass all other nations in geographical work. But we should almost infer that, when Cadmus brought letters from Phœnicia to Greece, as we learned in boyhood, he left no letters there; for, with all her wealth and opportunities, Phœnicia did little for literature or science. Wholly absorbed by the commercial spirit, she forgot all else. It is the same to-day. Commerce alone has never opened any great field to science. Arab traders have known the region about the sources of the Nile for centuries, but science was never the gainer. Some disinterested spirit must enter in. Patrons of science must send out explorers, or missionary workers must give their lives to opening up the dark places of the earth. In the last days of Tyre, however, one scientific name does appear—that of Marin. He collected some valuable information in regard to the east coast of Africa, of which Ptolemy made use. He also attempted in a crude way to use the method of projection in map-making.

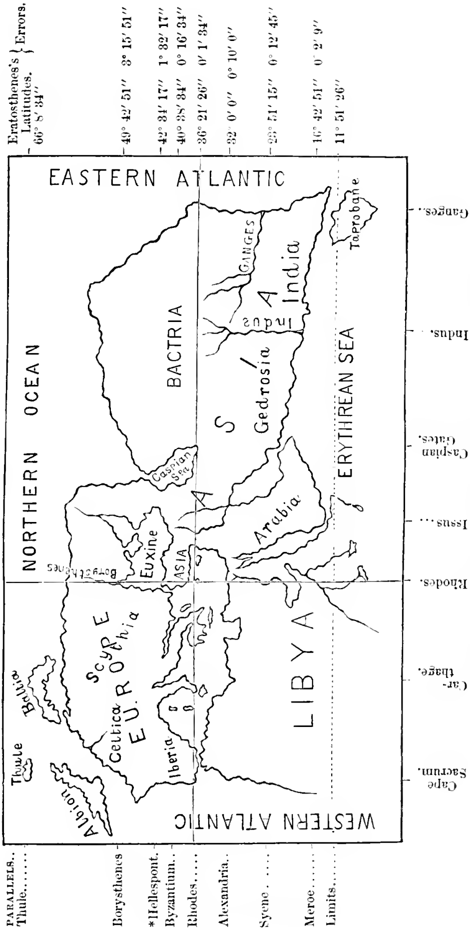
Lastly appears the great name of Ptolemy (middle of the second century). As the scholars of Alexandria had the honor of collecting and carefully editing all the great literary works of antiquity, preparatory to the centuries of darkness through which the world was to pass, so, under the hand of Ptolemy, was put into compact and durable form what had then been gained of geographical science. If he is the great man who makes grand use of his knowledge, then was Ptolemy greater than Hipparchus; for, what Hipparchus had thought out three centuries before him, Ptolemy now used to reëstablish—almost to transform—geographical science. He carried out both Hipparchus's plan of determining latitude and longitude by astronomical observations, and that of representing the earth by the modern method of projection—with the "curved meridians and parallels" which Strabo had despised. We can see from the errors which he makes that he did not fully understand Hipparchus's ideas, but he did measurably; and he had the energy to stamp his knowledge upon the world, and thereby became the master of geography.

To examine now the work of the two greatest geographers of antiquity, Eratosthenes the father, and Ptolemy the master.

We have seen Eratosthenes in the library of Alexandria, surrounded by every existing appliance of learning. Besides the data to which we have referred, he had before him what Hipparchus calls the "Ancient Map," possibly that of Anaximander, which Hipparchus prefers in some respects to the map of Eratosthenes. But, with all these appliances, he had not the one great essential to their accurate combination into a system of the world, viz., the length of the earth's circumference. He had, however, made certain astronomical observations that were to help him. By observing the difference of the shadows at the summer and winter solstices, he had calculated the angle of the ecliptic. He had also learned that the city of Syene, in Upper Egypt, was directly under the northern tropic, since there, at the summer solstice, the rays of the sun illumined the bottom of a deep well. Ascertaining by the gnomon, or by the armillary spheres, which he invented, the latitude north of the tropic of Alexandria, which he considered to be on the same meridian with Syene, he found the arc between Syene and Alexandria to be one fiftieth part of the earth's circle. Learning then from the itineraries that the distance between the cities was 5,000 stadia, he multiplied this by fifty and had his circumference, 250,000 stadia ; or, as he divided the circle into 360°, each of 700 stadia, he called the circumference 252,000 stadia. Not knowing the precise length of the stadium, we can not tell how exact this measurement was ; but to have measured the earth at all was surely a brilliant beginning of Eratosthenes's geographical work. His method, it may be said, is the same that is followed to-day in measuring the earth. Having, then, a basis upon which he can convert degrees into stadia and stadia into degrees, he proceeds to construct his map. He makes no recognition of the lines so prominent in all our maps of the world, the equator and the tropic, and polar circles ; but simply establishes a few parallels at irregular distances, viz., of the limits of the inhabitable earth—Meroe, Syene, Alexandria, Rhodes, the Hellespont, Byzantium, the mouth of the Borysthenes, and Thule. Some of the distances between these parallels were determined by itinerary measurements, some by astronomical observations. For example, the distance from Alexandria to Rhodes was determined by estimating the arc between the cities at the rate of 700 stadia to the degree. Again, the latitude of the Borysthenes having been determined by itineraries, and the latitude of Thule being known from Pytheas, as the same number of degrees from the pole that the tropics were from the equator, this distance was determined. The most important of these parallels was that of Rhodes, since upon this he measured the entire length of the world. He reckoned his measurements of longitude from Cape Sacrum in Iberia (now Cape St. Vincent), this being considered on a parallel with the Straits of Gades (Gibraltar), the Straits of Sicily, Rhodes, the Gulf of Issus (eastern extremity of the Mediterranean), the Caspian Gates (mountain passes south of the Caspian Sea), and Thinæ on the Eastern Ocean. Not having here any astronomical data, his longitudes are less correct than his latitudes. The principal points established are Carthage, the Straits of Sicily, and Rome, which he erroneously places on the same meridian, Alexandria and Rhodes, which he also places on the same meridian, Issus, the Caspian Gates, the source of the Indus, and the mouth of the Ganges. Though using a plane chart, he yet recognized the fact that a degree of longitude on the parallel of Rhodes had not the same value as at the equator, but was as 555 to 700, which is very nearly correct. Dividing now the distances from Cape Sacrum, which he gives us only in stadia, by 555, we find for Carthage a longitude of 21° 15′ 40″, which is only two degrees in excess of its true longitude; for Alexandria we have 45° 35′ 8″, which is an excess of between six and seven degrees; for Issus we have 54° 35′ 40″, making the Mediterranean too long by between nine and ten degrees; for the Indus the longitude of 100° 10′ 48″ is between twenty-three and twenty-four degrees too great; while for the Ganges 126° 7′ 34″ is an excess of between forty-five and forty-six degrees. These excesses, it will be seen, increase uniformly toward the east, as they would by using too short a measure for the degree; and since Eratosthenes expressly states that the degree at Rhodes is only four fifths of that at the equator, it has been conjectured that he has used stadia of different values. An argument in favor of this is that, if we use a stadium of such value that there would be 700 to a degree (as at the equator), the length of the Mediterranean would be very nearly correct, nearer indeed than upon any subsequent map down to the eighteenth century A. D., while the mouth of the Indus would be within three degrees of its true longitude. Knowing Eratosthenes's correctness upon other points, one can hardly resist the conviction that he did use stadia of different lengths, and that Strabo and Pliny have failed to quote his statement and explanation of the fact. We are further confirmed in this opinion when we consider that his age believed the inhabitable world to be very nearly twice as long as it was broad, and that this estimate makes its length to its breadth as 106 to 54.

Nevertheless, we have given here a representation of his map, in which 555 stadia, of the same length with the stadia of latitude, are allowed to each degree of the parallel of Rhodes.

We call attention to only a few of its noticeable features. First of all, the accuracy of most of its latitudes is to be noted, some of them being more accurate than those given by Gosselin, less than a hundred



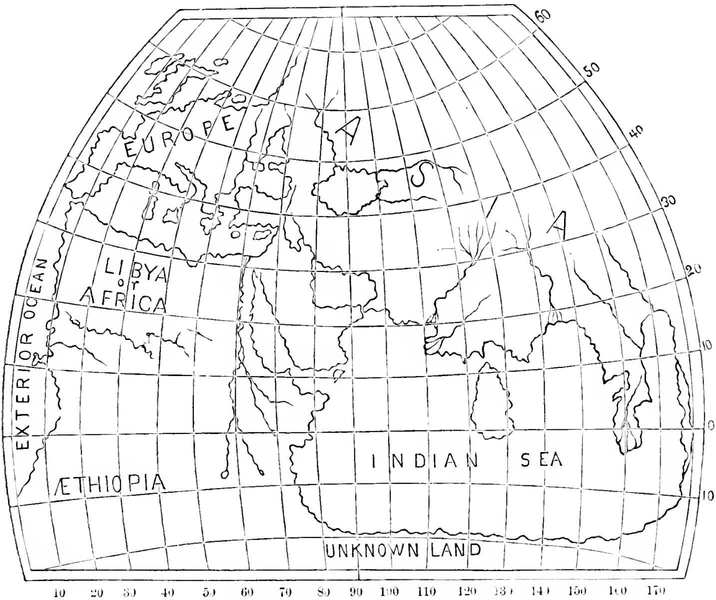
ERATOSTHENES'S MAP OF THE WORLD.

* *Erratum.*—Parallel of Hellespont, marked Byzantium and *vice versa.*

years ago. Not only is the Mediterranean unduly elongated, but the placing of the Sicilian Straits and Carthage on the same meridian, and Alexandria and Rhodes on the same, necessitates much too great a distance between the straits and Rhodes. Since the length of the Macedonian coast was placed within its proper limits, no way remained to adjust the distances but to prolong the Thermaic Gulf to the westward, and make of Greece a long peninsula stretching from west to east. The Caspian Sea, owing to reports that had been brought by certain followers of Alexander, appears as an arm of the Northern Ocean. The most striking feature, however, is the representation of India as extending east instead of south, with the Ganges flowing into the Eastern Ocean. This would seem to have arisen in this way: The mouth of the Indus had been reported by Alexander's officers too far south. It was also well known that from the Indus to the island known as Taprobane (Ceylon) there was a long stretch of coast such as is given in the map. But, if this extended southward, it would carry India below what was considered to be the limit of the habitable world, seen in the map at latitude 11° 51′ 26″. So it was turned away to the eastward. The distance from the Indus to the mouth of the Ganges had been learned through the mission sent to India by Seleucus; and, since the latter river did not enter the sea on the southern coast, it must have an eastern embouchure. But as the traditional limit of the earth—a length twice its breadth—was now reached, it only remained to extend the coast-line to the northward to complete the map.

In accordance with the principles upon which his map was constructed, Eratosthenes said that India could be reached by sailing westward from Spain—a suggestion by which Columbus is said to have been influenced. Before leaving Eratosthenes it may be mentioned that Gosselin contends that this ancient geographer had been preceded by geographers far better informed and more skillful than himself, and that all the best features of his map are due to them. Indeed, he claims that there was a period long before Eratosthenes, when the geography of Europe was as well known as in his (Gosselin's) day, and he even intimates that projected maps, similar to our modern ones, had then been used. His arguments in support of this, however, will not bear scrutiny.

Ptolemy, we have said, prepared the science for the ages of darkness on which the world was soon to enter. In a sense, the first shadows of that darkness had already fallen. The science had gone backward perceptibly since the days of Eratosthenes. True, there was a larger fund of information in regard to the countries of the Roman Empire; but, as we see in Strabo, there was no scientific grasp of the world as a whole. Ptolemy was therefore almost as much of an exception to his age as Hipparchus had been to his. Still he had helps which none of his predecessors had had, such as the works of Strabo and Pliny, and Marin of Tyre, for statements of facts, and those of Eratosthenes, and, above all, Hipparchus for scientific statement. The work which he composed with these helps was to be the standard and



PTOLEMY'S MAP OF THE WORLD.

only authority for more than thirteen centuries. Happily it has come down to us entire, though the different manuscript copies vary considerably among themselves. Through the generosity of the Emperor of Russia, fac-simile copies have been made of the oldest extant Greek MS., written about the year 1200 A. D., and now at Mount Athos; and these copies are in the more important libraries of the world. The method of projection which Ptolemy used in his maps had been slow of practical realization. Hipparchus's work had not gained a circulation. Marin of Tyre had had but poor success in attempting it, so that Ptolemy's approach to success seems the more commendable. We present a map drawn upon his system. In it are to be noticed two great errors. We have spoken of Posidonius as the originator of an error. Dissatisfied with Eratosthenes's measurement of the earth, he had measured it anew. To do this he had observed by a star the arc between Alexandria and Rhodes, and had ascertained the distance as nearly as he could from the number of days' sail between the cities. But soon becoming dissatisfied in regard to the distance he had employed, he adopted Eratosthenes's distance, which the latter had obtained by computing the arc at 700 stadia to the degree. With this distance, and with his own observed arc, he made such a computation of the earth's circumference as gave him 500 stadia to the degree. But the absurdity of thus employing the 700-stadium degree as an element in the computation, by which he obtained the 500-stadium degree, did not prevent even Ptolemy from adopting the latter estimate. A degree of 500 stadia at the equator gave him one of 400 stadia on the parallel of Rhodes. On this basis, reckoning from the Fortunate Isles (Ferro 18° 9′ 45″ west), he obtained the following longitude: Carthage 32° 20′, Rhodes 56°, Issus 66° 30′, Indus 122° 30′, Ganges 146°, Thinæ (conjectured to be Tenasserim, in farther India) 177° 30′—errors respectively of about four, ten, twelve, thirty, forty, and sixty-one degrees. These large errors he had no means of recognizing, but when he came to his latitudes he did have a corrective. Accepting, as he was disposed to do, Eratosthenes's distances, all his own latitudes became too high. Pytheas's Thule, instead of being at the arctic circle, would have been beyond the north pole. He therefore did what is so often done, allowed one error to force him into another, viz., the use of a degree of one length (500 stadia) for his longitudes, and of another length (700 stadia) for his latitudes. Like those of Eratosthenes, therefore, his latitudes are tolerably correct. A few features of this map should be noticed in comparison with former maps. Thule, which was unnoticed by Strabo, reappears, though it is not the Thule of Pytheas, but an island much nearer to Britain. The Sicilian Straits are no longer on a parallel with the Columns of Hercules, nor the straits and Rome on the same meridian. Alexandria and Rhodes are on different meridians, as also the Hellespont and Byzantium. The Caspian becomes again an inland sea. In the East, the great peninsula of the Deccan disappears, the island of Taprobane occupying its place. The Indian Ocean is an inland sea, Africa being connected by unknown lands with the lands of the far East.

In our map we have followed Gosselin's opinion that the Golden Chersonese was the region about the mouths of the Irrawaddy River, not the Malay Peninsula. But the most important of the minor features of the map, with which we must close our sketch, is its representation of the sources of the Nile.

Nili caput quærere was a work proposed to itself by the ancient as seriously as by the modern world. In the days of Herodotus the source of the river was considered a question of antiquity. The ancient dynasties, the Persian conquerors, and later the Greeks and the Romans, all made more or less of effort to solve the problem. We have seen how Herodotus answered the question. In the days of Eratosthenes, opinions were far more correct. Speaking of the Astaboras (Atbara), and the Astapus or the Astasobas (Blue Nile), he says, "Certain authors pretend that this last name applies to another river, *which flows from lakes situated to the south*, and forming the principal affluent of the Nile." This is the first definite reference to the southern lakes, and how a knowledge of them had then been gained we do not know. It seems certain that no one in ancient times had ascended the river to them. Expeditions were repeatedly sent out with this object, notably one by Nero, which ascended higher than any other, but was finally stopped by impenetrable marshes, apparently in about 9° north latitude. But in ancient as in modern times the problem was finally approached in a different way. Marin of Tyre had furnished Ptolemy with information in regard to the east coast of Africa. Traders had gone as far south as the promontory of Prasum (Cape Delgado), and doubtless information gained there in regard to Madagascar had given rise to the conjecture of lands inclosing the Indian Ocean. But in trading along the coast these men had heard of two lakes in the interior, which were called the sources of the Nile. Ptolemy would seem to have made particular inquiries about these lakes, for he says that a Greek trader had told him that they were farther inland than he had supposed. He accordingly placed them, as seen in our map, in latitudes 6° and 7° south, and longitudes 57° and 65° east, or on either side of the meridian of Alexandria. Information like this was worthy of the greatest geographer of antiquity, and which should not so long have been despised; for it was only when modern explorers, following ancient traditions, went in from the coast of Zanzibar, that they—not solved but *re*-solved the ancient problem of the sources of the Nile.

EXPECTED METEORIC DISPLAY.

By RICHARD A. PROCTOR.

IT is expected, by nearly all astronomers who have given attention to the subject, that there will be a display of falling stars on or about November 27th next, though the night of the shower may perhaps fall earlier or later, within a week or so either way. The display, should it occur, will possess far more interest than any ordinary shower of shooting stars, or even than the displays which have been witnessed on the night of November 13th–14th, in 1799, 1833, 1866, and other years. For, though we now know that when these showers of Leonides (as the meteors of November 14th–15th are called) occur, the earth is passing through the track of a comet which is followed by uncounted millions of meteors, and the like when on the nights of August 10th, 11th, and 12th the meteors called Perseids are seen, yet the comets corresponding to these longer-known meteoric showers are less interesting to astronomers than the comet along whose track those bodies travel which produced the shower of falling stars seen on the night of November 27, 1872, and which are expected to produce a similar display this year. It was well remarked by M. O. Struve, at the last meeting of the German Astronomical Society, that no object has thrown more light on the general nature of cometic bodies than the comet known as Biela's. I propose now to give a brief sketch of the history of this interesting body, and then to consider the reasons why astronomers expect that during the last week of November, 1879, there will be a display of shooting stars as the earth passes through the comet's track.

In the year 1826 Biela discovered a comet, the path of which was calculated by Gambart, a French astronomer, insomuch that, according to the usual rule in such cases, the comet should be called Gambart's, not Biela's. It was found to revolve around the sun in a period of about six and two thirds years. It was not a conspicuous body—in fact, it has seldom been much more than barely visible under the most favorable conditions by the naked eye. Yet it differed from most telescopic comets in showing not only a nucleus and a coma, but a tail also. In 1832, 1839, and 1846, this comet returned to the earth's neighborhood, and on two of these occasions it was well seen. In 1839 it was so situated as to be lost in the sun's rays. In fact, at every third return astronomers knew that it would be hopeless to search for the comet. Thus, it was discovered in 1826, and well seen in 1832, but not seen and not even looked for in 1839. So, again, it was seen in 1846 in its calculated place, and again in 1852, but it was not looked for in 1859. In 1866 and 1872 it should have been visible, but, as will presently be explained more fully, it was not seen. In this present year, 1879, supposing all had gone on as in the forty preceding years, the comet would not have been visible, passing too near the sun's place in the sky. Astronomers have been set to search for it this year (but quite fruitlessly), because there were reasons to believe that, if seen at all, the comet would not be seen on its former track. But we must not pass to this part of the comet's history until the strange circumstances connected with former returns and with former expected returns of the comet to visibility have been briefly considered.

In the year 1846, when Biela's comet was well seen, it divided—or rather, after having apparently been single, it was seen to be divided—into two distinct comets, each having coma, nucleus, and a short tail of its own. These two comets traveled along side by side until they passed out of view; but in 1852 both returned into view, though the distance between them was then greatly increased. Whether in 1859 the companion comets would have been seen had the earth been more favorably situated, is not known. The comet was not even looked for in that year, so hopeless did the search seem for so faint an object, close as the comet then was to the sun's apparent place in the sky. But in 1866 the comet should have been seen as favorably as in 1846. The superintendent of the "Nautical Almanac" published an ephermis of the comet's motions—in other words, he stated where the comet was to be looked for day after day, and a number of the most skillful practical observers in Europe searched carefully for it, but it was not seen. "There was not the slightest room," I wrote in 1872 (and, despite the opinions which have been since expressed by several astronomers, I see no reason for changing my opinion), "for questioning the accuracy of the calculations by which its path had been predicted. Astronomers were certain that, if undestroyed or undissipated, the comet would follow the assigned path—as certain as a station-master would be that a train would enter a station along the line of rails assigned to it, unless some accident or mistake should occur. But comets do not make mistakes, though, as we now see, they are not free from accidents. This comet had already met with an accident, being broken by some mischance into two parts, under the very eyes of astronomers. Possibly in 1859 it met with further misadventures. At any rate, something had happened to the comet since its retreat in 1852. 'It is now,' Sir J. Herschel wrote in February, 1866, 'overdue. Its orbit has been recomputed, and an ephemeris calculated. Astronomers have been eagerly looking out for its reappearance for the last two months, when, according to all former experience, it ought to have been conspicuously visible, but as yet without success—giving rise to the strangest theories. At all events, it seems to have fairly disappeared, and that without any such excuse as in the case of Lexell's, viz., the preponderant attraction of some great planet. Can it have come into contact or exceedingly close approach to some asteroid as yet undiscovered? or, peradventure, plunged into, and got bewildered among, the ring of meteorites, which astronomers more than suspect?'"

But, as I pointed out at the time, there was a convincing objection against the first of these theories in the circumstance that, the two comets into which Biela had separated being more than a million miles apart when they passed out of view in 1852, it was not in the least likely that *both* would be so far perturbed by asteroidal perturbations as to remain thenceforward undiscoverable. "It would be a singular chance," I said (this was before November 27, 1872, when fresh light, presently to be noted, was thrown on this object), "which should bring one of these objects into collision with a minor planet, or so near as to occasion an important disturbance. But, supposing this to happen, then the fellow comet, not traveling in the wake of the first, but side by side, would certainly have escaped. For it must be remembered that, although 1,250,000 miles is a very small distance indeed by comparison with the dimensions of the solar system, it is an enormous distance compared with the dimensions of the minor planets, some of which have a surface not much greater than that of an English county. The minor planet occasioning the comet's disturbance would presumably be one of the smallest, since it has not yet been detected, and the newly-discovered planets are on the average much smaller than those first detected. Now, the earth herself would have no very marked influence on a comet or meteor passing her at a distance of 1,250,000 miles; for it is to be remembered that the comet as well as the earth would have an enormously rapid motion, and the disturbing power of the earth would therefore only act for a short time. But a minor planet—even the largest of the family—would not have the twenty-thousandth part of the earth's power to disturb a passing comet. At a distance of 200,000 miles a comet would pass such an asteroid without any marked disturbance of its motions," and at a distance of 1,250,000 miles there would practically be no disturbance at all. "It is, of course, not absolutely impossible that one of the comets of the pair should have been encountered by one minor planet, and the other by another, but the probability against such a contingency is so great, that we need scarcely entertain the idea even as a bare possibility."

On the other hand, the supposition that the comet was destroyed or dissipated by meteor-streams, though not altogether untenable, seems little likely to be correct. I was disposed, when I wrote the article from which I have quoted the above passages, to think otherwise. "The comet," I said, "had been seen to divide into two parts in a portion of the solar system where certainly no bodies but meteorites can be supposed to travel. It seems reasonable to suppose that on that occasion the head of the comet had come upon some group of meteors, and so had divided, as a stream of water divides against a rock. Assuming this, we find reason for believing that the track of this comet crosses a rich meteor region. The particular group which had caused the division of the comet would of course pass away, and would not probably come again in the comet's way for many years or even centuries; but another group belonging to the same system might in its turn encounter the comet, and complete the process of dissipation which the former had commenced. On this theory the distance between the companion comets would introduce no difficulty. For not only is it quite a common circumstance for meteoric systems to have a range of several millions of miles, but—a much more important consideration—*both* the comets would be bound to return to the scene of the former encounter. It was *there* that each had been sent off on a new track, but each new track started *from* there, and therefore each new track must pass through there." The reasoning here is correct enough as far as it goes, but it does not duly take into consideration the extreme sparsity of meteoric distribution and the extreme tenuity of the heads and even of the nuclei of comets. As I pointed out in an essay which appeared in the "Popular Science Review" two months only after the essay from which I have quoted above had appeared in the "St. Paul's Magazine" (if I remember rightly), the meteors of even one of those comparatively rich clusters which produce an important display are strewed so sparsely that each occupies on the average a space corresponding in volume to a cube one hundred miles in length, breadth, and height. The largest meteor in the solid form is probably not many inches in diameter (I am speaking, be it remembered, of the meteors producing displays of ordinary shooting stars or falling stars, not of those masses which thrust their way through the upper regions of the air, and, exploding, cast their fragments often over many square miles of the earth's surface). It will be understood how small is the chance that a flight of bodies so minute compared with the average space occupied by each could cause the dispersion of a mass so rare, and therefore so free to pass through a meteor-flight without disintegration or disturbance, as a comet.

How Biela's comet came actually to be divided into two distinct bodies, and later to be so far dissipated as to be no longer visible even in the most powerful telescopes and under the most favorable circumstances, will probably be understood when we know the nature of those processes of repulsion which lead to the formation of comets' tails. For our present purpose it is only necessary to observe that these processes of repulsion do most obviously carry away parts of the substance of a comet's head to enormous distances, and that, in some way, Biela's comet was divided, even as it were under the eyes of astronomers, into two distinct comets; for we thus learn to recognize the further disintegration of the comet as part of a process undoubtedly commenced in 1846 and undoubtedly competent to effect the dissipation of the comet's substance. As the comet was searched for in vain in 1866 in the region which unquestionably it would have traversed had it remained unchanged, there can be no reason for doubting that it had thus been thoroughly dissipated and disintegrated. If anything could have made this more certain, it would have been the circumstance that in 1872, also, the comet was searched for in vain. Remembering that the observations made during the first few weeks after the comet's discovery in 1826 gave astronomers such a mastery over its motions that they could successfully predict its return in 1832, and show precisely where it would appear, nay, even calculate back its path and recognize its identity with a comet discovered by Montaigne in 1772, and rediscovered (though not recognized as the same) by Pons in 1805, it is obvious that in 1866, after several carefully observed returns and nearly a century after its first discovery, the comet's motions must have been much more thoroughly understood. It would have been much more easily detected that year than in 1846 and 1852, even as Halley's comet was much more easily detected at its return in 1835 than at its return in 1759.

If the comet had been like most of its fellows, astronomers must have given up all idea of obtaining further information respecting it. But in one important respect it differed from them. It is one of the few known comets whose paths cross, or at least pass very close to, the track of the earth. Already in 1832 attention had been called to this circumstance. Indeed, fears had been excited among those unfamiliar with astronomical relations by the announcement that the comet would cross the earth's path in that year, although it was explained that the comet would pass a month before the earth reached that point of her path. "We escaped that time," Sir John Herschel wrote in 1866. "Had a meeting taken place, from what we know of comets, it is probable that no harm would have happened, and that nobody would have known anything about it." But from what we have since learned we have reason to believe that we should have known a great deal about the encounter, though it remains altogether probable that no harm would have happened. For we have learned that as a rule the tracks of comets are followed by millions of meteoric bodies, which, as the earth passes through the flight, produce displays of falling stars, each meteor in its rush through the earth's atmosphere producing a trail or streak of light; and doubtless in the head itself of a comet meteoric bodies are much more richly strewed, so that an encounter with the head would produce an unusually splendid display of falling stars. It is, however, very noteworthy, as will presently appear more clearly, that no display of meteors is recorded as having occurred in the last week of November, 1832, though the comet had crossed the earth's track less than a month before. Yet in 1872 astronomers were led to expect somewhat confidently that, as the earth passed the track of Biela's comet, which had gone that way only some ten or twelve weeks before, there would be a shower of falling stars produced by the bodies following in the comet's path.

I may pause here, by the way, to remark on the clear way in which this expectation, and what was actually observed, should show every one who has clear mathematical conceptions that it is the train, and not the tail, of a comet, which is followed by meteoric attendants. Professor Tait, of Edinburgh, who is a master of mathematical analysis, but apparently wanting in the power of clearly conceiving geometrical relations, has based on the mistaken idea that comets' tails are made up of meteors a wild theory of the phenomena presented by these appendages, a theory which could not be accepted even if it had been proved that comets' tails are formed of meteor-flights. For he explains the appearance of a long cometic tail as due to the circumstance that at the time the earth is in the plane of a vast meteoric stratum attending on the comet, though it is certain that not one of the known long-tailed comets can have kept its stratified meteoric tail (assuming always that it had one) directed with its plane earthward during half the time of the tail's actual visibility. But so far as real evidence is concerned, the probability is that there are no meteors in or near the tail of a comet. *For, on the one hand, on the only occasion when the earth is known to have passed through the tail of a comet—namely, when she passed through the tail of the splendid comet of 1861—no meteors were seen which could have belonged to that appendage; and on the other, in every single case in which meteors have been associated with a comet, those meteors have not been in or anywhere near the* *comet's tail.* As I have said, Biela's comet is a case in point, and so obviously in point that it is difficult to understand how any mathematician could follow the history of the case without at once recognizing the error which nevertheless has misled and still misleads Professor Tait. That double comet, with its tails projecting from the sun, crossed the earth's path in or about the first week of September, 1872, traveling on a path slanted to the plane of the earth's orbit at an angle of twelve and a half degrees, and with a velocity considerably exceeding that of the earth in her orbit. Moving at this rate, and with this inclination, the companion comets would of course attain in ten weeks a position many millions of miles south of the plane of the earth's orbit. Thus a line from the sun to either comet would not, where prolonged into the tail, approach within many millions of miles of the earth's orbit—that is, of any position which the earth can possibly occupy. Both comets were even farther away from the actual position occupied by the earth at the time when, nevertheless, astronomers predicted a star-shower, and when, as they predicted, such a shower occurred. For the comets had left that place ten or twelve weeks before, and nearly the whole of the comets' motion had carried them away from that place, whereas only a small part of their motion had carried them away from the plane of the earth's orbit. In fact, no one who had studied with any attention the circumstances of any predicted meteor-display could have fallen into the mistake made by Professor Tait, a mistake actually so elaborated as to be made the basis of an entirely novel, and for other reasons utterly impossible, theory of comets' tails.*

* I may here remark that the tone of the above paragraph is, in my opinion, altogether objectionable, considered in itself. It is almost impossible even for the most careful students of science to avoid making mistakes from time to time, and occasionally mistakes of the most egregious nature. There is scarcely one of the great thinkers whose work has most effectively advanced science, who has not made mistakes even in dealing with his own special subject; while those who, like the Herschels, Humboldt, and others, have dealt from time to time with subjects outside their own labors, have naturally been exposed to more serious misapprehensions. It is not wonderful that Professor Tait, engaged chiefly in analytical and physical researches, should fall into errors in dealing with astronomical matters, as when he discusses comets' tails, the solar corona, and so forth. But such errors should be corrected genially and pleasantly, not sneeringly (which, indeed, I have not done) nor censoriously. I must point out, however, that Professor Tait lays himself open to the severer forms of correction by the perfect savagery of his own corrections of mistakes made by those who chance to have offended him. The man who, in his lecture on "Force," so fiercely denounced Tyndall for mere errors, or, rather, inexactnesses of verbiage which could mislead none; the man who jeeringly exclaimed, "These be thy gods, O Israel," because one of the greatest physicists of the age omitted, in defining work done in raising bodies, to mention that such bodies were on the earth, not on Jupiter or elsewhere; the man who has even honored me by his sneers at real mistakes of mine, and who with ingenious garbling has invented mistakes for me which I had never made (apparently for no other reason than because I pleasantly expostulated with him on one occasion for his attacks on Tyndall)—can hardly object to be corrected in the hard though not harsh tone adopted above. If the *tu quoque* defense be considered insufficient, then let me note that Professor Tait, by advancing a theory capable of being tested by evidence without being at the pains so to test it, and by refusing even to ex-

The predictions made in November, 1872, were not so precise as they would probably have been if the comet had been seen in 1866 and in 1872, as had been expected. Indeed, astronomers had very little experience as to the meteors of Biela's comet. They were in doubt what showers among those recorded by various observers of meteors as occurring during the last week of November and the first week of December could be associated with this particular meteor system. For until the astronomical significance of meteoric displays had been fully recognized, the observers of shooting stars, even when these were seen in showers, had been more careful to record the brightness and the number of the meteors than their course among the stars. So that the criterion which at present distinguishes one meteor system from another, even though both meteor systems may show falling stars on one and the same night or at one and the same time, is not applicable to most of the records of star-showers. That criterion, it need hardly be said, is the position of what is called the radiant point of the star-shower, the point from which all the meteor-tracks on the sky seem to tend. The reader must not fall into the mistake of supposing that every meteor-track absolutely extends from the so-called radiant. On the contrary, it may truly be said that not one such track does or can extend from that point. But each tends from the point in the sense that, if the course pursued by the meteor be supposed to be extended backward in a straight line (or, more correctly speaking, in a great circle of the heavenly sphere), the line would pass through the radiant point. The expression is used in the same general sense, and has, in fact, the same significance as the statement usually made about parallel lines and their vanishing point in perspective. Lines which are really parallel are so drawn in perspective that they all tend from one and the same point, but they do not extend from it. An artist might indeed draw them all in pencil from that point, but he would afterward rub out parts of the pencil-lines, leaving the rest all tending from the vanishing-point, but none of them extending actually from it.

Now, what is the radiant point of a meteor system? It is in reality that infinitely remote point from which all the meteors seem to be traveling—the point toward which all the parallel lines on which they are actually traveling seem to converge. No meteor, then, approaching the earth on the course thus indicated could possibly seem to move actually from the radiant point. If moving directly toward the observer, it would be visible *at* the radiant point, all the time, not seeming to move *from* it; if not moving directly toward the observer, but on a course parallel to that from the radiant point to the observer, it would be seen, from the beginning to the end of its flight, at points removed from the radiant, but all on a line tending from it. Thus the

amine the evidence brought forward by others, has committed an offense against scientific morality (scientific morality only, be it understood) such as he can allege against none of those whom he so warmly denounces.

actual path pursued by a meteor may be on one side of the heavenly sphere, while the radiant is on the other; precisely as any particular yard of a set of parallel railway lines and telegraph wires may be to the right or the left, or above or below, or may be *behind* an observer, while the point from which all these lines converge is in *front* of him. Yet two meteor-tracks, carefully observed, will suffice, unless absolutely coincident, to show the radiant point belonging to them, assuming of course that they belong to the same system. And when on any night many meteors of the same system are seen, the radiant point of the system, which indicates the direction from which with respect to the earth they all seem to travel, can be most accurately determined. In this way each meteor system is perfectly distinguishable from all others; and also, from the position of the radiant point of a system, the question whether the meteors are or are not bodies following in the track of any known comet, can be at once set at rest. The path of such bodies can be calculated with perfect exactness. The apparent path resulting from the combination of their motions with the motions of the earth can equally well be determined. This gives the radiant point of such bodies, if such bodies there are, as they appear in shooting-star displays in our skies. No scattered meteors, still less any meteor-shower, can be mistaken for attendants on such a comet—at least, if we set aside the bare possibility (for such it is) that bodies really traveling in a different course may appear to travel on the same course. This can happen; but it is so exceedingly unlikely, that if a meteor-flight appears at the time, and from the radiant point, corresponding to the attendants of a particular comet, it may be confidently assumed that they really are such attendants.

But, as I have said, on former occasions when displays of meteors occurred during the last week in November or the first week of December, which might therefore have indicated the earth's passage through the train of Biela's comet, no special observation was made of the tracks of individual meteors, so that it was not possible to ascertain afterward whether such showers might or might not be thus explained. Nor were any observations made for Biela meteors when the earth passed through the track of the comet in 1836, when, from what we now know, a display of such bodies might have been expected.

It was otherwise in 1872. Biela's comet itself having been searched for fruitlessly, several astronomers called attention to the circumstance that in the last week of November the earth might be expected to pass through a train of meteors following in the track of the now disintegrated comet. They showed also how Biela meteors, if such existed, could be distinguished from other shooting stars; the radiant point corresponding to attendants on Biela's comet lying in the region where the constellation Andromeda borders on Cassiopeia, near the feet of the former of these celestial bodies. I myself wrote in the following terms, in a paper written in October, and which appeared in the "St.

Paul's Magazine" for November, 1872: "There will probably be a display of meteors following the track of Biela's comet. At any rate, the skies should be carefully watched. The shower of meteors (should one occur) will fall in such a direction that shooting stars might be looked for at any hour of the night. Those belonging to Biela's comet could be very readily distinguished from others, because their tracks would seem to radiate from the constellation Cassiopeia. So that should any one observe, on any night between November 25th and December 5th, a shooting star following such a track, he will have the satisfaction of knowing that in all probability he has seen a fragment or portion of a comet which has divided into two if not three distinct comets, and has followed up that process of dissipation by dissolving altogether away."

The prediction thus made was abundantly fulfilled. On November 27, 1872, there was a display of shooting stars second only in magnificence among those seen since the middle of the present century to the shower observed in the early morning hours of November 14, 1866. In numbers, indeed, the shooting stars of November, 1872, fully equaled, if they did not exceed, the shooting stars of November, 1866. Professor Grant, of the Glasgow Observatory, counted no fewer than 10,579 meteors between 5h. 30m. P. M. and 11h. 50m. P. M. Four observers in Italy, who severally limited their observations to the four quarters of the heavens between the four cardinal points, counted in six and a half hours 33,400 shooting stars. It appears that the greatest number were seen between 7h. and 9h. P. M. Between 6h. 55m. and 6h. 56m. the whole of the sky around the radiant of the system seemed to be occupied by a meteoric cloud. This region lay, as predicted, near the feet of Andromeda. There remained no doubt that the earth on the night of November 27th had crossed a stream of meteorites, following in the track of Biela's comet.

But now followed what gave rise to considerable misapprehension, by which it would seem that even some mathematicians of considerable skill have been misled. A German astronomer, Klinkerfues, telegraphed to Pogson, the Government observer at Madras, "Biela touched earth November 27th; look for it near Theta Centauri": meaning, doubtless, what was in reality the case, that the earth had passed through the meteoric train of Biela, and that it might be worth while to look out for the retreating flight in the part of the heavens directly opposite the point from which the meteors had seemed to arrive. Whether Klinkerfues meant this, or whether, as some seem to suppose, he meant that possibly Biela's comet might have been delayed ten or twelve weeks, and so have certainly encountered the earth on November 27th, need not for the moment be considered.* Suffice it that Pog-

* Strangely enough, Mr. Hind, the Superintendent of the "Nautical Almanac," has written (in "Nature") as though the comet had been in some way delayed ten or twelve weeks between 1852 and 1872, so that the earth did actually "touch Biela," as Klink-

son examined the heavens in the region indicated, and there, in the early morning hours of December 2, 1872, detected two cloud-like objects. These he saw again on the morning of December 3d—by which time their position on the star-vault had changed, so that it was clear they were not nebulæ or star-clouds, but veritable attendants on the sun, though whether comets or meteor-flights was not clearly made out. It was, however, clearly shown that neither of these objects could possibly have been the meteor-flight crossed by the earth on the night of November 27, 1872. It was equally certain that neither the meteor-flight nor these two cometic objects could have been Biela's comet itself—though all three were traveling in such courses that they might be called attendants of that body.

There for the time the history of Biela's comet has closed. Nothing more has been seen of it, either as a comet or as a meteor-flight, though scattered meteors traveling in its train were seen toward the end of November, 1877, and more would probably have been seen at the same part of last year if the skies then had not been overclouded in nearly all European countries.

The next passage of the earth athwart the track of the comet is the first, since that of November 27, 1872, during which a meteor shower could be expected to occur. The comet crossed the earth's track, or passed very near to it, early in April last; and though the interval is considerably longer between then and the end of November than elapsed between the comet's passage in 1872 and the display of that year, yet it is most probable that many meteoric attendants of the comet will be seen on some nights (or perhaps on several nights) between November 25th and December 1st, and quite possible that a very fine shower may be seen. The meteors will be well worth looking for in any case, since, if they are carefully observed and counted hour by hour, astronomers will probably obtain some further insight into the nature of the processes which lead to the dissipation of a comet and cause its path to be occupied over a range of many millions of miles by scattered meteoric attendants. To others than astronomers, the meteors will be full of interest; and it is not at all unlikely that they will appear in such numbers as to produce an exceedingly beautiful display.—*Belgravia.*

erfues telegraphed to Pogson, "on November 27, 1872." But this is quite impossible. Any perturbation active enough to delay the comet's perihelion passage ten or twelve weeks would have entirely changed the character of the comet's orbit. But the very circumstance that the earth crossed the train of cometic attendants on November 27, 1872, showed that they were in the track of the comet, whose path could not, therefore, have been greatly altered. The case may be simply put thus: Either the comet's motions *had* been or *had not* been very greatly disturbed between 1852 and 1872: now, if they had been, the comet's path would no longer have passed near the earth's, and the comet could not have encountered the earth either on November 27, 1872, or at any other time; and if they had not been, the comet must have crossed the earth's track early in September, 1872, and therefore, in this case also, must have been far away from the earth on November 27, 1872.

MANY-TOED HORSES.

WHEN Professor Huxley gave his lectures in New York, three years ago, on the evidences of evolution, he brought forward the genealogy of the horse as made out by recent fossil discoveries, and claimed that it was decisive in establishing the principle of descent, derivation, and development through the geological periods. There was a good deal of wise shaking of heads and shrugging of shoulders, at his presentation of the case, on the part of many who attended the lectures ; and all who were perfectly ignorant of comparative anatomy and could not comprehend the course and force of the argument, were certain that the great biologist had for once made a total failure. No doubt if these critics had been questioned they would have readily pronounced the case closed for ever against evolution ; but knowledge grows and evidence accumulates, and so it will be worth while to recall the subject, that we may appreciate some of the further points of illustration that have been made out since.

Professor Marsh, of Yale College, who has had this inquiry especially in hand, has made a short communication to "Silliman's Journal," on "Polydactyle (many-toed) Horses, Recent and Extinct," the substance of which we here reproduce.

It is stated that America is the original home of the horse, and that during the whole of Tertiary time, which the geologists divide into three periods—the Eocene, Miocene, and Pliocene—early, middle, and later—this continent was occupied with horse-like mammals of many and various forms. These all became extinct before the discovery of the country, but their abundant remains furnish the materials for marking out the genealogy of the horse in an almost unbroken succession of forms.

The study of fossils has shown that the oldest representatives of the horse on this continent all had many toes, and were of small size. In the course of development there was a gradual increase in size and a diminution in the number of toes, until the present type of horse was produced. The line of genealogy has been made out through seven successive stages, and the fossil proofs of its validity and completeness are all to be seen in the Yale Museum of Natural History. In vol. x. of "The Popular Science Monthly," page 295, the figures are given that illustrate the whole subject ; we here simplify the representation by indicating the succession of changes that have taken place in the structure of the fore-foot of this series of quadrupeds (Fig. 1). All the facts go to show that the horse tribe is derived from an original ancestor having five toes on each foot, but this parent of the race has not yet been discovered. The oldest member of the group that has become known is the *Eohippus*, which had four well-developed toes and the rudiment of another on each fore-foot, and three toes behind.

It was about as large as a fox, and appears in the lower Eocene or at the base of the Tertiary formation. It was discovered since Professor Huxley's lectures were given, and since the diagrams we follow were made, and we therefore have no figure of it. The *Orohippus*, in the next higher division of the Eocene, resembled its predecessor in size, but had only four toes in front, as the diagram shows. The *Mesohippus* came later, was about as large as a sheep, and had three usable toes, and the splint of another, on each fore-foot. In the later *Miohippus*, the splint-bone is reduced to a short remnant. In the Pliocene above, a three-toed horse (*Protohippus*), about as large as a donkey, was abundant; and, still higher up, a near ally of the modern horse (*Pliohippus*) makes his appearance. The series is completed in the subsequent appearance of a true *Equus*, as large as the existing horse.

The horse has thus advanced in his development by getting rid of superfluous toes or digits; but, under the principle of reversion to an early ancestral type, to which it is now well understood that animals are liable in various ways, these suppressed splints or digits break out as extra hoofs. Professor Marsh says: "In addition to each main digit of the ordinary horse, the anatomist finds concealed beneath the skin two slender metapodial 'splint-bones,' which are evidently the remnants of two other toes originally possessed by the ancestor of the horse. It is an interesting fact that these splint-bones are sometimes quite fully developed, and may even support extra digits which are much shorter and smaller than the main foot. As these small hooflets

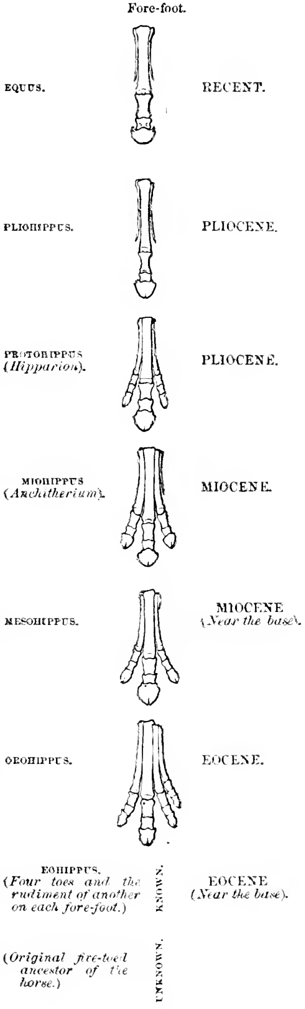


Fig. 1.

are usually regarded as a serious detriment to the animal, they are generally removed from the colt soon after birth; but, in such cases, the enlarged splint-bones not unfrequently indicate in the adult their former existence. Numerous cases of extra digits in the horse have been recorded, and in nearly all of them a single lateral hooflet was present on one of the forelegs."

Professor Marsh states that the first recorded instance of extra digits in the horse known to him are two mentioned by George Simon Winter, in his famous book on horses, published at Nuremberg in 1703. One of the horses referred to, and figured in this work, was "eight-toed," having a small extra digit on the inside of each foot. Winter states that this horse was exhibited in Germany in 1663, and a portrait of it preserved in Cologne. His account was derived from a person who had examined the animal. The other horse described by Winter had a small hoof in the inside of each fore-foot; and this steed, Winter states, he had not only seen but ridden. Other instances of this phenomenon are referred to, on the authority of Geoffrey Saint-Hilaire, Owen, and Leidy.

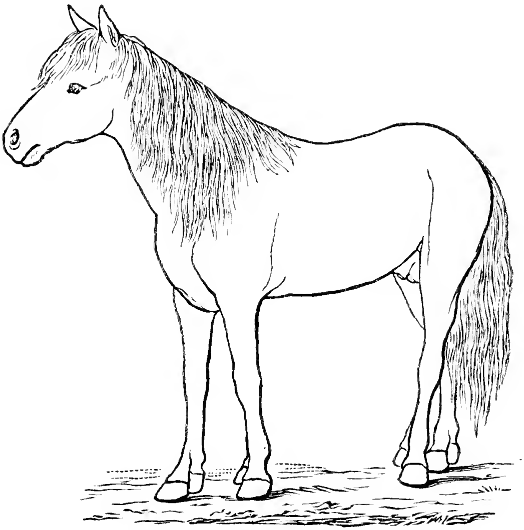


Fig. 2.—Outline of Horse with Extra Digit on Each Foot.

Professor Marsh has described an interesting case of this reversion in the horse, which he has personally examined, and which is represented in Fig. 2. He says: "This animal was on exhibition in New

Orleans in the spring of 1878, and Dr. Sanford E. Chaillé, of that city, first called the attention of the writer to it, and likewise sent a photograph from which the cut was made. This same horse was subsequently brought to the North, and a few days since was on exhibition at New Haven, Connecticut, where the writer examined him with some care. The animal is of small size, about ten years old, and is said to have been foaled in Cuba. He is known among showmen as the 'eight-footed Cuban horse.' With the exception of the extra digits he is well formed. The four main hoofs are of the ordinary form and size. The extra digits are all on the inside, and correspond to the index-finger of the human hand. They are less than half the size of the principal toes, and none of them reach the ground.

"Among the instances of recent polydactyle horses described to the writer by those who have seen them are two of special interest. One of these was a colt with three toes on one fore-foot, and two on the other. The animal recently died in Ohio. Another is a mare, raised in Indiana, and is still living, which is said to have three toes on each fore-foot, and a small extra digit on each hind-foot. In regard to the latter animal, the writer hopes soon to have more definite information.

"Besides the instances mentioned above of extra digits in place in the existing horse, there are many cases on record of true monstrosities, as, for example, additional feet or limbs attached to various portions of the body. Such deformities now admit of classification and explanation, but need not be considered in the present discussion."

SKETCH OF HEINRICH WILHELM DOVE.

By FREDERICK HOFFMANN.

THE veteran *savants* who inaugurated the great advances in modern physical research are passing away, one after another, leaving their achievements for completion to the succeeding generation, and their imperishable fame to the records of human history. Foremost among the centers of exact and productive inquiry and learning ranked the University of Berlin, founded in the years of Prussia's deepest humiliation at the hands of the great Corsican adventurer, out of the royal motive "to raise the down-trodden nation to strength and greatness by intellectual and mental vigor and virtue." Among the brilliant array of famous scholars of the first period of that university were Wilhelm and Alexander von Humboldt, Leopold von Buch, Carl Ritter, Fichte, Hegel, Enke, Boekh, Kunth, Link, Ehrenberg, Johannes Müller, E. Mitcherlich, Heinrich and Gustav Rose, Poggendorf, Dove, Magnus, and others. Dove, being one of the youngest, outlived them all.

Heinrich Wilhelm Dove was born at Liegnitz, Silesia, on October 6, 1803, and at the age of eighteen passed from the schools of that town to the Universities of Breslau and Berlin, where for the next three years he devoted himself to the study of mathematics and physics. In 1826 he took the degree of Doctor of Philosophy at the University of Berlin, his thesis on the occasion being an inquiry regarding barometric changes; and it is significant of his future life-work that his first published memoir was a paper on meteorological inquiries relative to winds, these two subjects holding a paramount place in the great problem of weather-changes.

Dove began his public career as a professor at the University of Königsberg, where he remained till 1829, being then invited to Berlin as supplementary Professor of Physics. His strikingly clear-sighted, bold, and original intellect turned forcibly to that intricate group of questions in the domain of physics which comprise the sciences of meteorology and climatology. In these fields, then but imperfectly understood, his success as an original explorer was so marked and rapid that it at once attracted the attention of the scientific world and of the governments throughout Europe; and these were but the first of a long series of consummate researches and deductions by which Dove, besides Humboldt, opened new fields of inquiry and laid the foundation of those sciences. Stimulus and encouragement were not wanting; for he entered upon his brilliant career at a time when a most productive era prevailed in the rise of the exact physical sciences in Germany: Goethe was still living, the glory and the giant mind of his age; Alexander von Humboldt had stirred the world of science and culture by his ever-famous popular lectures on physical and cosmical geography, in the great hall of the Berlin University in 1827 to 1828, and his fascinating "Views of Nature," translated into most civilized languages, had delighted and inspired all Europe; the first German Geographical Society had been established in Berlin in 1828, second in time only to that of Paris, the oldest European Geographical Society. Ehrenberg* had returned from his six years' explorations in Africa and Asia with immense treasures of collections and geographical and meteorological observations. Leopold von Buch, geologist and geographer, stood in the zenith of his fame. Carl Ritter, the father of comparative geography, inspired both the youth and the learned of Germany by his masterly exposition of that science in his lectures and writings. Dove, then in the prime of youth, soon took a foremost rank as a lecturer at the university, and among the cultured circles of the Prussian capital; the combined qualities of accomplished scholarship, of vivid and clear exposition, of fine imagination, of humorous and sarcastic wit, combined with a commanding presence, and the extent over which his elo-

* "Popular Science Monthly," vol. xiv., p. 668.

quent utterances were heard, marked him as the Arago and Brewster of Germany. For more than a quarter of a century his audiences were among the largest and most accomplished in the great hall of the Berlin University, overcrowded as it was by students and scholars of all ages and from all stations in society and in the army. Germany showered on him in profusion those honors which it but sparingly bestows except on the highest order of learning and science; and other countries amply recognized the successive results of Dove's masterly researches; there is scarcely a learned or scientific society of any note that has not his name enrolled among its honorary members. The Berlin Academy of Sciences elected him, in 1837, one of its youngest members; and in 1845 he was raised to the distinguished position of the chair of Physics in the University of Berlin, now held by his successor Professor Helmholtz.* When Alexander von Humboldt died, May 6, 1869, the insignia of the high order *pour le mérite*, worn by him, were bestowed upon Dove; and in 1867 he was chosen Vice-Chancellor of that most exalted rank for scientific achievement in Germany.

It would far surpass the limit allotted to this brief sketch to enter in detail upon the scientific labors and works of Dove; his scientific papers published in the memoirs of the Berlin Academy of Sciences, in Poggendorf's "Annalen," in "Zeitschrift für Erdkunde," in "Zeitschrift des Preussischen Statistischen Bureau's," etc., between the years 1827 and 1876 number more than two hundred and fifty, besides his larger published works and treatises, of which the most noted are:

"Über Maas und Messen," 1835; "Meteorologische Untersuchungen," 1837; "Über die Nichtperiodischen Veränderungen der Temperatur-Vertheilung auf der Oberfläche der Erde," 6 vols., 1840–1859; "Untersuchungen im Gebiete der Inductions Electricität," 1843; "Über den Zusammenhang der Wärme-Veränderungen der Atmosphäre mit der Entwicklung der Pflanzen," 1846; "Temperaturtafeln," 1848; "Über Electricität," 1848; "Monats Isothermen," 1850; "Verbreitung der Wärme auf der Erdoberfläche durch Isothermen und Isanomalen," 1852; "Darstellung der Farbenlehre," 1853; "Monats-und Jahres Isothermen in der Polarprojection," 1864; "Darstellung der Wärme-Erscheinungen durch fünftägige Mittel," 3 vols., 1856–1870; "Die Witterungs-Erscheinungen des nördlichen Deutschlands," 1858–1863; "Das Gesetz der Stürme," 1857; "Optische Studien," 1859; "Anwendung des Stereoscopes zur Erkennung falschen Papier Geldes," 1859; "Die Stürme der gemaessigten Zone," 1863; "Klimatologische Beiträge," 2 vols., 1857–1869; "Klimatologie von Nord Deutschland," 2 vols., 1868–1871; "Eiszeit, Föhn und Sirocco," 1867; "Der schweizerische Föhn," 1868; "Der Kreislauf des Wassers auf der Erde," 1868; "Gedächtnissrede auf Alexander von Humboldt," 1869, etc.

They show Dove to have been a most thorough and successful

* "Popular Science Monthly," vol. v., p. 231.

worker and investigator in electricity, magnetism, optics, crystallography, and in such practical subjects as measures and weights, and the metric system of civilized nations. Among other discoveries, he also first recognized the presence of a secondary electric current in a metallic wire, at the moment that the circuit of the principal current is completed. The large number of physical instruments originated and devised by his genius and skill, among them his polarization apparatus, his differential inductor, his rotating polariscope, and numerous other important devices, bear evidence of his many contributions to the advancement of physics.

But it was to meteorological, hydrographical, and climatological inquiries that Dove devoted his full strength and the great powers of his mind; and by his comprehensive and well-directed labors he has written his name in imperishable characters on the records of science. His fame rests preëminently on the successful inquiries which he carried out with a view to the discovery of the laws regulating atmospheric phenomena, which apparently are under no law whatever, and on his isothermals and isabnormals of temperature for the surface of the globe, in which labors one can not sufficiently admire the breadth of view which sustained and animated him as an explorer, during the long, toilsome years spent in, and requisite to, their preparation. Equally characterized by philosophic depth and by what really seemed a love for the drudgery of detail, even to profuseness, when such drudgery appeared necessary or desirable in attaining his object, are his various works on winds, the manner of their veering, and their relations to atmospheric pressure, temperature, humidity, and rainfall, and the important bearings of the results on the climatology of the globe; and on the relation of the variations of temperature to the development of plants and their life and distribution. The origin of storms and their connection with the general circulation of the atmosphere has been much elucidated by Dove's comprehensive and exact researches; and the "laws of the rotation of the winds and storms," of so vast importance to the mariner, are for ever linked with his name.

Alexander von Humboldt had originated the Prussian Meteorological Bureau, and Dove, since 1848 its director, gradually organized, extended, and summarized throughout Germany, the valuable system of meteorological observations and publications, since widely and successfully accepted and introduced in most civilized countries.

When we consider the condition in which Dove found man's knowledge of the weather, and the large accessions and development it received from his hand, the breadth of his views, and the well-directed patience rising into high genius, with which his mind was inspired and his researches were pursued, there can be but one opinion, that these give Dove claims, which no other physicist can compete with, to be styled "the Father of Meteorology."

So much of Dove as an original investigator and scholar. As professor at the Berlin University he accomplished more than one hundred lecture terms (Semester), and among the many thousands who have been instructed and inspired by his masterly and impressive lectures and occasional orations, most of the eminent physicists of our generation and the scientists of Germany may be counted, who all will remember with pleasure and veneration the great teacher's exquisite style, his humor and wit, the lucidity and precision of his logic and demonstration, and the elegance and perfection of his experiments. He did not address himself to beginners, but presupposed the full intellectual maturity and learning of the German gymnasium education, and his audiences were composed of men of every age and of the highest stations of society. Dove was also for years Professor of Physics at the Military and the Polytechnic Academies of Berlin, and a member of the highest boards of the Prussian Government for state examinations in the various branches of civil and military vocations. Governments, learned institutions, and societies from many countries resorted to him as the highest authority.

The celebration of Dove's fiftieth year of his Doctorate in Philosophy, March 4, 1876, was the occasion of well-deserved felicitations from all parts of Germany, from the people and Government, and from institutions and seats of science and learning. The feeling was general that the fifty years of Dove's active life in a very large degree represented and reflected the recent history of physics, and of meteorology and climatology in particular. Congratulations and honors poured in upon the veteran *savant* from all parts of the civilized globe, as his name and fame were well known, and his labors and achievements are still of inestimable value on all continents and to the mariner on the seas. Three years later, after a protracted illness, Dove passed peacefully away on the 4th of April, 1879, in the seventy-sixth year of his age, one of Germany's greatest and most gifted naturalists and teachers of the present century.

CORRESPONDENCE.

CURIOUS EFFECT OF LIGHTNING.

Messrs. Editors.

THE following remarkable freak of lightning seems to me worthy of record: There was a severe shower, accompanied by vivid lightning and peals of thunder, in Salem, Massachusetts, August 6, 1879. A lady, while passing through a room in range of two open windows, was suddenly enveloped in a blaze of light from her feet to her waist. She was not in any way unpleasantly affected by it, but from a sense of fright threw herself on the bed beside a friend; both detected the smell of sulphur and of burned leather. Nothing more was thought of the matter till two days after, when the lady went to her dress, which had hung in a closet ever since the afternoon of the storm, to get her purse from the pocket. The purse contained eighty-five dollars in greenbacks. What was her astonishment, when it was opened, to find the money gone, and in its place only charred fragments of the same and ashes! The remnants of the bills were adherent to the sides of the central pocket in which the money was contained. Nothing was left of it sufficient to identify it as bills. The pocket of the purse in which it was held was surrounded by a rim of nickel with a central clasp. The clasp was bent and blackened. The band was riveted on by two steel pins. A car-ticket in an adjoining compartment of the purse was blackened; a silver half-dollar was blackened and also bent. The purse was not burned or marred externally, but there was a crisp, burned spot at one end. The purse was in a cotton pocket between two woolen stuffs. It has been seen by hundreds, and by all it is considered a remarkable freak of this most subtile agent.

M. J. SAFFORD.

BOSTON, *July* 26, 1879.

WHY DO WELLS AND SPRINGS OVERFLOW?

Messrs. Editors.

I HAVE read with interest the paper in your November number, "Why do Springs and Wells overflow?" The theory advanced by the writer is ingenious, but it would have been more satisfactory if he had told us how the water which is forced out of subterranean reservoirs in the manner he describes is first forced into them. He says, "If fissures exist in rocks that lead to imprisoned waters, through these outlets the water must certainly flow." Then, of course, such fissures can never serve as *inlets;* for the same cause—"the resultant of the force of gravity and the centrifugal force"—which sends the water out, would for ever prevent any water from sinking in. If the rainfall, as I suppose he would admit, is more or less remotely the source of supply for these reservoirs, or if they have any source external to themselves, and are not miraculously inexhaustible, his theory seems to involve a contradiction.

I am, sir, in the interest of science, very respectfully yours,

J. T. TROWBRIDGE.

ARLINGTON, MASSACHUSETTS, *October* 27, 1879.

ON ATLANTIS.

Messrs. Editors.

DEAR SIRS: I have read the article on "Atlantis" in your October number, but can not agree with its conclusions. It is unlikely that any such geological convulsions could have taken place in times when mythology was forming, and if they had done so the myth based upon them could not have taken so realistic a shape. We must agree that myths are petrified descriptions of natural processes expressed in language which can now only be understood figuratively. I think, then, there is room for the probability that the Atlantis myth is founded on the observation of low-lying clouds in a sun-flushed sky which looked like islands in a golden sea. Yours respectfully,

A. R. GROTE.

SOCIETY NATURAL SCIENCES, BUFFALO, *October* 1, 1879.

EDITOR'S TABLE.

GOLDWIN SMITH ON MORALS.

PROFESSOR GOLDWIN SMITH is a student of history, and in the November "Atlantic Monthly" he has given us the fruits of his historical studies in relation to morality. He contributes an article on "The Prospect of a Moral Interregnum," which, being interpreted, means a moral break-down. He says that morality is based upon religion, and that in the past the collapse of religious systems has always been followed by periods of moral debasement. He then shows that in the present age there is an extensive decline of religious belief, which promises, and has already brought forth, another period of moral debasement. Goldwin Smith is an eloquent writer, and always sure of a large number of readers; whatever he says, therefore, is entitled to attention, and this article is entitled to *especial* attention. We dissent from some of his views, and propose to give the reasons for it.

His first historic illustration is from the Greeks. Hellenic life, public and private, is stated to have been full of religion, while the fear of the gods was a mainstay of morality. "Hellenic religion, however, was entangled with a gross mythology, immoral legends, a worship of sacrifices, a thaumaturgic priesthood, an infantine cosmogony, a polytheistic division of the physical universe into the domains of a number of separate deities." We are told that it fell before awakened intellect, while its fall was conducive to progress; but morality felt the withdrawal of its basis, as is variously shown, especially in the pages of Thucydides.

Rome is next taken up, and we are informed that here also public and private virtue was sustained by reverence for the gods. Polybius is quoted as attesting the strength of the religious sentiment among the Roman people, and the necessity of maintaining superstitions "as a concession to the requirements of the multitude." But the Roman religion, like the Greek, broke up, though "practical good sense probably played a more important part in the overthrow of superstition at Rome than in Hellas." This was followed by widespread immorality, but it is admitted that the case is complex: "At the same time a tremendous strain was laid on public morality by the circumstances of the empire. There ensued a cataclysm of selfish ambition, profligate corruption, and murderous faction, which left to society only the choice between chaos and a military corruption."

Professor Smith next points out the marked religious character of life and society in the middle ages under Catholic predominance, and enumerates many moral conquests of that period. Besides the triumphs of religious art there grew up the conception of the brotherhood of mankind, the sanctity of life, the value of virtues other than military, and the happy transition of society from slavery through serfage to free labor. "Catholicism fell through the superstitions and impostures which had gathered around it, and which intellect, awakened by the Renaissance, spurned away; through Papal tyranny and clerical corruption, through the general ossification, so to speak, of a system which had once in all its organs ministered to spiritual life. With it fell the morality that it had sustained, and once more we find ourselves in a moral interregnum."

Now, if we assume that these are correct historical representations, what is the obvious inference? Why, that religion has hitherto proved an insecure foundation for morals. Be there or be there not an indestructible core of truth in all religions, morality, according to Professor Smith, has been planted upon their perishable parts, their mutable elements, and has lost its hold upon men as these have passed away. A foundation that crumbles and permits its superstructure to fall is a bad foundation; and the real question forced upon us by Professor Smith's historical lessons is, Shall we continue to build the edifice of morals upon this unstable basis, or shall we seek a better and more enduring basis? Are the rules of conduct to be derived from what men know concerning this world, or what they conjecture concerning another? Or will it be maintained that morals can have no other possible foundation than that which history and experience have proved to be incapable of supporting it?

Professor Smith assumes that history will repeat itself. He draws a vivid picture of the extent and depth of the prevailing unbelief, and insists that it must be followed by the same perilous decline of morals as in former times.

But he here overlooks the altered condition of the question. He seems to have forgotten that the circumstances in this age are profoundly different from what they were in the former great periods of religious decadence. In those times, when a set of superstitions was worn out and discarded, the state of knowledge was not such as to prevent their reëntrance in new forms. But it is not so in this scientific age, when the doubt of traditions is due to an increasing knowledge of nature. The profound and widespread questioning that characterizes our time is charged upon science, which is a new factor in human affairs of modern growth, and in so far as it is connected with science it springs from allegiance to truth. The skepticism engendered by science is not a blind passion for sweeping things away, but everything is examined, that it may be proved what will stand. The active mind of the period is vigorously engaged in getting opinions off of their illusive traditional foundations, that they may rest upon their intrinsic merits and go for what they are honestly worth. Doubt does not lead to negation, but to construction. The search for principles, and trust in them when established, are becoming, through the influence of science, intellectual characteristics of the time. Morality has its principles; and right and wrong are grounded in the nature of things. Goldwin Smith goes for the sandy foundation of mythology and theology, which may lead to further moral collapses; while science is unweariedly laboring to avoid them by planting morality upon a basis that will be permanent.

It is significant that Professor Smith never refers to any element of truth in his religious foundation of morals. These foundations, however, consist of fear of fabulous gods, superstitious legends, and perishable dogmas, and he declares that now for the fourth time on a great scale they have rotted away. Morality has, therefore, not rested on any divine, immutable basis, but upon crude and transitory belief, mere human devices. But is it not a vicious system which plants morals upon a basis that can be carried away by the necessary progress of knowledge? And what more effectual way could be devised to subvert morality than to make it depend upon that which is not valued for its truth, and is liable to be discredited at every step of advancing intelligence? In short, what immorality can work such profound and far-reaching evil as to place the motives and rules of human conduct upon a false, factitious, and transitory basis?

From this point of view there is a fallacy in representing morality as based upon religion, as a statue stands upon its pedestal. Morality and religion have grown up together, supernatural beliefs being mixed with ethical ideas as with everything else. Astronomy was mixed up with religion in the astrological periods. Chemistry was mixed up with religion in early times when the alchemist always began his experiments with prayer. But who would say that astronomy and chemistry were based upon religion? In the progressive differentiations of knowledge they have become freed from superstitions, and are now independent branches of science. Morals is later in its separation, but it must follow the same law, and become also an independent branch of science. But in these past interactions Professor Smith does not tell us to what extent religious superstitions have corrupted morality and hindered its development; nor does he intimate to what extent the life of such superstitions may have been prolonged by the conservative influence of their accompanying codes of morals.

But the Professor comes to closer quarters with his subject when he asserts that the moral debasement resulting from change of religious belief is a matter of fact, and already upon us. Religion *has* succumbed, and its place is taken by materialism, agnosticism, and evolution. A frightful catalogue of public crimes is made out and charged upon evolution. His curious logic here is, that evolution involves the conception of force, and therefore represents the execrable doctrines of brute force, outrage, and violence in human affairs. He says: "The worship of success signally exemplified in the adoration of a character such as that of Napoleon seems to be the morality of evolution supplanting that of Christianity." The "seeming" is here quite illusive. Evolutionists as a class are neither worshipers of success nor adorers of Napoleon. The parties addicted to these practices will be found in the opposite camp. The most signal and representative example of this adoration that we know was that of a Christian clergyman, the Rev. John S. C. Abbott, who wrote the life of Bonaparte in a strain of extravagant eulogy, and found hundreds of thousands of Christian readers who shared the admiration of the reverend author for his hero. It was not in the school of evolution that Abbott and his multitudinous readers were trained to the worship of brutal military success.

Mr. Smith cites the barbaric policy of England in the treatment of inferior races, the Zulu and Afghan wars, and the English sympathy with the slave power during the American civil war, as further illustrations of that ascendancy of brutality which he considers due to the present prevalence of evolutionary doctrine. The proposition is preposterous. The worship of success and the practice of national atrocities upon inferior races are not things of yesterday. They belong to the historic policy of Christian peoples. Afghan and Zulu wars are not novelties in English experience. Many in England may have sympathized with the slaveholders in our war, but what of the history of the slave system itself in relation to religion and morality? Were the negroes stolen and enslaved by evolutionists or Christians? Did religion abolish or nourish that stupendous immorality during the two centuries of its growth? Did not religion through its organizations lend itself to the perpetuation of this "sum of all villainies," which was only at last brought to an end solely by the indiscretion of its partisans, who went a little too far, and thus brought on the horrors of a fratricidal war?

And as to war itself, the subversion of all morality and the very revel of brute force, has it not ever been the pastime of religious nations? And do regiments ever want for chaplains to bless their brutal and bloody vocation?

Professor Smith further illustrates the ascendancy of brute-force ideas in

England by citing the case of Governor Eyre. He says: "Moral phenomena of the same kind marked the controversy arising out of the Jamaica massacre; the enthusiastic supporters of Governor Eyre perfectly recognized in him an organ of the sanguinary vengeance of the dominant race, even if they did not believe that he had committed a foul judicial murder."

But still the question is, Upon whom is this savagery chargeable? Professor Smith says it is a result of the present predominance of evolution supplanting Christian morality. He utters "the thing that is not." Who was it that held up Governor Eyre to reprobation, prosecuted him, and demanded his punishment? And who was it that excused his conduct and organized to defend him? It was Carlyle, the great apostle of the brute-force philosophy, who was very properly chairman of the committee of defense; and he was backed up solidly by the Christian lord-bishops. But no one, except under the desperate necessity of making out a case, will charge that either Carlyle or the bishops were animated by evolutionary sentiments. On the other hand, John Stuart Mill, the agnostic, was chairman of the committee that prosecuted Governor Eyre, and on that committee, and among the most earnest and vigorous in its work of resisting the control of brute force, were the eminent evolutionists, Charles Darwin, Professor Huxley, and Herbert Spencer. Professor Smith ought to have more respect for the facts of his case.

MORALITY AMONG THE CHINESE.

Early in his article in the "Atlantic," Professor Goldwin Smith says: "Be the significance of the fact what it may, a fact it seems to be, that only men with a religious belief and a sanction for morality which they believe to be divine, have been able to live under a government of law." Yet a few pages further on he remarks: "China is without any real religion; she is thoroughly positive."

Professor Smith will reconcile these propositions as best he can with the fact that China is the oldest government and the largest nation in the world. She has a recorded history of more than four thousand years, and gives law to one third of the human race. It will be instructive to glance briefly at the state of morality among these "positivists," that we may see how it compares with that of confessedly religious countries.

It will be remembered that our information concerning the Chinese is largely from prejudiced sources—from missionaries who went there to get them out of their heathenism, and the official representatives of foreign governments bound to open this dark region to the light of civilization. These witnesses will, at any rate, not be biased in favor of the Chinese.

In the last edition of the "Encyclopædia Britannica" it is said, "Education is probably more widely spread among the male population in China than in any other country." The British Governor, Sir John Davis, in his able work on this country,* says: "It is deserving of remark that the general prosperity and peace of China have been very much promoted by the diffusion of intelligence and education through the lower classes. Among the countless millions that constitute the empire, almost every man can read and write sufficiently for the ordinary purposes of life, and a respectable show of these acquirements goes low down in the scale of society." S. Wells Williams, missionary, interpreter, and secretary to the British Legation in China, in his "Middle Kingdom" says, "Education has always been highly esteemed and exerted a dominant influence on the manners and tastes of the people."

* Davis's "China," addressed to Lord Palmerston, vol. i., p. 257.

Now, this universal Chinese education differs widely from ours. It is not a smattering of acquisitions of all kinds; it is an able, well-tried system of training, narrow but thorough, and directed to the practical end of fitting men for the discharge of their moral duties in domestic and social life. Williams remarks: "The great end of education, therefore, among the ancient Chinese, was not so much to fill the head with knowledge as to discipline the heart and purify the affections. One of their writers says: 'Those who respect the virtuous, and put away unlawful pleasures, serve their parents and prince to the utmost of their ability, and are faithful to their word—these, though they should be considered unlearned, we must pronounce to be educated men.'"

Five hundred years before the Christian era China produced one of the most eminent moral teachers that the world has seen—the philosopher Confucius. The simple, pure, and sublime morality of that old master forms the staple of Chinese education. His ethical inculcations constitute the chief element of the old Chinese classics, which are drilled with such tedious minuteness into the minds of Chinese youth. They are trained in his maxims with an assiduity that is unparalleled. Rational or scientific morality is taught nowhere. It is everywhere a matter of dogmatic, empirical lesson-learning, and from this point of view the moral education of the Chinese is superior to that of any other country. And here has been the stumbling-block of the missionaries. They have not been successful with this people, and acknowledge that they have nothing to encourage them to keep on save "Scripture promises." What else could be expected? When they tell those persons that "their righteousness is all as filthy rags," and that they want a theological system as a basis of morals, it is not surprising that they make but very little impression.

The authorities we have quoted attest that this extensive moral teaching has not been without practical influence upon the national character. The variety and minuteness of the instructions of Confucius for the nurture and education of children, and the stress he lays upon filial duty, tell powerfully upon Chinese social life. The "Encyclopædia Britannica" says (article "China"): "There is a vast deal of quiet, happy domestic life in China. . . . *In the ordering of a Chinese household there is much that might be imitated with advantage by European families.* The duty of filial piety, which is the first object of Chinese religious teaching, represents much more than the ceremonial observances which outwardly mark its performance. The reverence with which children are taught to regard their parents fosters the affection of which that reverence is the outward and visible sign; and the peace of each household is assured by the presence of a supreme authority against whose dicta there is no appeal." Such principles pervading the household can not be restricted in their influence, and accordingly we are told that in China "the whole theory of government is the embodiment of parental and filial piety."

In regard to the common virtues, the same authority says: "In daily life the Chinese are frugal, sober, and industrious. Their wants are few, and they are easily satisfied. . . . Spirits—they have no wine—appear to have no great attraction for Chinamen. They drink them occasionally, and sometimes to excess, but a reeling Chinaman is rarely to be seen upon the streets."

The "American Cyclopædia" (article "China") says: "As to the moral and intellectual characteristics of the Chinese, great injustice has been done to them. . . . The Chinese, so far as they have come in contact with Europeans and Americans, are industrious, skillful, polite, and provident. . . . In the use of food and drink they are remarkably temperate. . . . Cookery is almost esteemed as a science in China. Mr. Wingrove Cook assigns to the Chinese in cookery a middle position—below the French and above the English. The Chinaman considers the Englishman's mode of feeding the nearest approach to that of the savages of Formosa; 'for,' says he, 'the Englishman does the chief work of the slaughter-house upon his dinner-table, and he remits the principal work of the kitchen to his stomach.' . . . The social life of the Chinese is generally described as a mass of ceremonials and cold formalities, devoid of all real kindness of heart; but this opinion is based upon incomplete observations. In their common intercourse the Chinese are not more formal than is elsewhere considered to be well bred. Whether in the crowded and narrow thoroughfares, the village green, the bustling market, the jostling ferry, or the thronged procession, wherever the people are assembled promiscuously, good humor and courtesy are observable."

The Chinese are eminently a peaceable people. In this respect they conform more perfectly to the theoretical standard of Christian morals than any Christian nations. Duels are unknown among them; and they consider a resort to force as proof of an inferior kind of civilization. They are conservative, and dread all violent disturbance. Governor Davis says, "They have lived so much in peace that they have acquired by habit and education a more than common terror of political disorders"; and again, "Their common maxim is, 'Better be a dog in peace than a man in anarchy.'"

The ancient and permanent policy of the Chinese Government has accorded with the spirit of its population, and has been peaceful. "Happy the people whose history is wearisome," remarks Montesquieu; and Governor Davis observes, "If this be the character of Chinese history—if we find the even current of its annals for a long time past (before the late rebellion) less troubled by disorders and anarchy than that of most other countries—we must look to the causes in the fundamental principles of the government, and in the maxims by which it is administered." * Such habits of life are of course not favorable to the virtues of the prize-ring and the battle-field. Christians have hence reproached the Chinese for practicing the pacific morality of Christ, and, because they have not been given to internal discord and external war, have accused them of cowardice—the leading characteristic, by the way, of the American militia. If the reader will look over the first article in the November "Atlantic Monthly," on "Our Military, Past and Future," he will find it proved that, in the various wars that make our annals such lively reading, American citizens have always proved the most arrant cowards, who will never stand up to fight unless they have been so long subject to military discipline that all manliness is drilled out of them, and they become mere puppets, good for nothing but to obey orders. And it further turns out that the "courage" of even the old disciplined soldier, in nine cases out of ten, is a differential result of his opposing fears, and that he fights the enemy because he is more afraid of his friends.

We used to hear many years ago about a quality called *moral courage*, and the stand for principles in defiance of brute force; but since our great war less has been heard of that very unmilitary virtue. It will therefore be refreshing to recall a conspicuous Chinese instance of it. On the 28th of December, 1857, a mile of gunboats, English and French, were drawn up in line before the city of Canton. They summoned the Viceroy to surrender, but he did not comply. The allies then opened fire, and kept up for many hours

* Davis's "China," vol. i., p. 249.

a hot bombardment. Nothing entitled to be called resistance was offered; there was no enemy. Having battered down a sufficient number of dwellings, and got tired of their "glorious" sport, the allies stopped the cannonading. A squad was then sent to demand of the Viceroy Yeh the formal surrender of the town. "We shall surrender nothing," was the reply, "because we are right, and you are wrong." "Then we will take you prisoner." "You have the power." "Come with us, then." But the Viceroy did not move. Thereupon they lifted up the chair in which he sat, and carried him on board Lord Elgin's ship. As to who were the real victors in this case may be safely left to the future verdict of civilization; unless, indeed, General Grant anticipates it in the great work on "The Philosophy of the Chinese Policy," which it is to be hoped he will soon publish.

Mr. Wells Williams remarks,* "It was about A. D. 600 that Taitsung, of the Tang dynasty, instituted the present plan of preparing and selecting civilians by means of study and degrees." That is, more than twelve hundred years ago China adopted its present thoroughgoing policy of competitive civil-service examinations to secure honesty and efficiency in the discharge of political duties and trusts. Whatever may have been its results, England, within a generation, has adopted a similar system, confessedly in imitation of the Chinese. We, too, have feebly tried to secure something of the kind; but such is the degraded condition of American political morality that the effort has been little else than a ridiculous farce. Perhaps Goldwin Smith will show us that the beastly condition of our politics is due to "evolution supplanting Christian morality."

It is said that the Chinese are untruthful; but Mrs. Opie, in her classical book on lying, did not have to go to China for her illustrations either of the nice gradations or the great popularity of this practice. She dealt with it entirely as the phenomenon of a religious country. Moreover, as we are just fresh from a political campaign, perhaps the less we say about veracity the better, even in comparison with the pagans. An intelligent gentleman, many years a resident of China, and accustomed to large business transactions with their merchants, informs us that among these merchants in the great centers of commerce the standard of mercantile honor is higher than anywhere else in the world. The tea and silk sent us from China are no doubt often adulterated, which is, of course, very immoral; but the highest English authority, Dr. Hassall, declared, in his big book upon the subject, that in his country every article under heaven that can be adulterated *is* adulterated.

"But they are such dreadful opium-smokers!" ejaculates the complacent tobacco-chewing deacon, as he seeks the spittoon. Very true; and we are not bringing forward these godless heathen as models of all the virtues. But speaking of opium recalls another passage in Chinese history, which throws light on this comparison of Christian and pagan morality. The Chinese Government undertook to suppress the opium-traffic, so as to cut off the foreign supply and arrest the demoralizing influence of its use among the people. Profoundly impressed by the dreadful evils of this increasing habit, the authorities did their utmost to stop the smuggling of the article; but, when its vigorous measures began to be effective, the great Christian nation which was embarked in the villainous trade, made war upon the country, and forced the accursed drug upon it at the cannon's mouth. The conduct of England in this "opium war" will be infamous through all time; but its policy was as deliberate as its motives were execrable. In the preliminary discussion of

* "Middle Kingdom," vol. i., p. 422.

the subject in the British Parliament, before war was declared, no considerations of morality or humanity were recognized, and Wells Williams informs us that Lord Melbourne but echoed the common sentiment when he said, "We possess immense territories peculiarly fitted for raising opium, and, though he would wish that the Government were not so directly concerned in the traffic, he was not prepared to pledge himself to relinquish it." And when the war was over "members of Parliament expressed their gratification at being at last out of a bad business; while now the light of the gospel and the blessings of Christian civilization might be introduced among the benighted millions of China."

The war was over for the English, and they had gained their disgraceful object; but the end had not come for the Chinese. The spell of their pacific history and the prestige of the imperial Government were broken together. In a previous quotation Governor Davis speaks of the peaceful current of Chinese history till the disturbance of the "late rebellion." He refers here to the great Taiping rebellion, which threatened the subversion of the established Government, and which Governor Davis says "can be *clearly traced* to changes produced by *our war*"—the opium war.

The Taiping rebellion broke out in southern China in 1850. There had been repeated failure of crops in the district where it originated, followed by suffering and disaffection. A man of humble origin, named Hung Siutsuen, seized the occasion to incite an outbreak. He had failed in the civil-service examinations, and had no prospect of office under the Government. He had read some of the tracts issued by the missionaries, got a notion of Christian supernaturalism, gave out that he was a recipient of divine messages, assumed the title of "Heavenly Prince," and conceived the idea of founding a new religion and at the same time of expelling the existing dynasty. His schemes were favored by the foreigners, who professed to believe that the cause of Christianity would be promoted by their success. The insurrection was pushed with great vigor and effect. Battles were won, towns captured, districts ravaged, and multitudes of people butchered, while the Government was able to check the disastrous movement but partially. For centuries "the empire had been peace"; the Christians had suddenly brought war and instituted the reign of brute force, and with this the nation, by its habits and circumstances, was but poorly prepared to cope. The rebellion, accordingly, smoldered along for sixteen years before it was finally suppressed. The foreign officials, seeing at length that there was little chance of succeeding with Christianity as they had with opium, and that the rebellion meant simply anarchy, the destruction of law and order, with danger to trade, threw their influence at last in favor of the existing Government, and helped to end the insurrection.

Surely the morality of these pagan positivists, said to be without any real religion, does not suffer in comparison with that of a nation which boasts of a "great religion" at the foundation of its moral system.

ROOD'S CHROMATICS—A MISLEADING CRITICISM.

We early expressed a high opinion of Professor Rood's work on Chromatics, both as an admirable popular exposition of the science of colors and also as to its bearing on their artistic management. This estimate has been ratified by discriminating criticism both in leading American journals and the best English periodicals—all of which have been emphatic in their commendation of its judicious and instructive treatment of the artistic relations of the subject. It was not without some surprise, therefore, that we read in the "Nation," of October 16th, a review of this work, which, though in some respects cordially appreciative, was in important respects at variance with the common verdict. The writer speaks of the scientific character of the book in a very pronounced way as "a work so laden with untiring and skillful observation and so clear and easy to read, that it is plainly destined to remain the classical account of the color-sense for many years to come." But before he gets through he talks in so different a strain as to occasion some perplexity with reference to his real state of mind upon the subject.

The critic in the "Nation" raises the question whether scientific investigation can be of use to artists, and he assumes that Professor Rood believes it may be. That question, however, we do not here propose to consider, but merely to show that the writer in the "Nation" has been both unfair and unfortunate in the examples he cites as proof of the bad consequences flowing from the assumption he attributes to Professor Rood. He says: "As to the question whether scientific investigation is an aid to artistic production or to artistic judgment, the author seems to assume that it may be. In the preface it is asserted that while knowledge of the laws of color 'will not enable people to become artists,' it may help in artistic work. Now, whether this is so or not, there is no chance to discuss in these columns, but a chapter of Professor Rood's book might well have been devoted to the examination of that question, and we regret to find instead of such examination the whole argument of the last two or three chapters resting upon the assumption of what we think ought to have been proved." Again he says: "The last chapter is devoted to the use of color in painting and decoration; and in this the evident knowledge and right feeling of the author are made useless by the false system adopted—the system of arguing from assumed principles to results instead of comparing results together with the view of establishing principles." As an example of this "false system," the fact is then pointed out that four pages are devoted to statements respecting the good, bad, and indifferent combinations of colors in pairs.

The fact is, however, that Professor Rood has taken especial pains, in the very instances selected, to explain that the method complained of is precisely the one he has *not* followed; and that the information contained in the tables is not derived from scientific experiments, but by observation of the results of artistic experience. Professor Rood has carefully guarded himself here in the very opening paragraph of the chapter "On the Combination of Colors in Pairs and Triads." He there says: "In the previous portion of this work we have dealt with facts that are capable of more or less rigorous demonstration; but we now encounter a great series of problems that can not be solved by the methods of the laboratory or by the aid of a strictly logical process. Why a certain combination of colors pleases us or why we are left cold or even somewhat shocked by another arrangement, are questions for which we can not always frame answers that are satisfactory even to ourselves. There is no doubt that helpful and harmful contrasts have a very great influence on our decision, as will hereafter be pointed out; but, besides this, we are sometimes influenced by obscure and even unknown considerations. Among these may perhaps be found inherited tendencies to like or dislike combinations or even colors; influence of the general color-atmosphere by which we are surrounded: training; and also a more or less delicate susceptibility. The author gives below, in the form of tables, some of the results furnished by experience, and takes pleasure in acknowledging his indebtedness to Brücke and to Chevreul for much of the information contained in them."

These tables, then, are given as embodying the results of artistic experience solely, and contain a comparison of artistic results collected "with a view of establishing principles." The different triads of colors that are mentioned further on in the chapter belong in the same category: we read on page 299 that "the triads that have been most extensively used are spectral, red, yellow, and blue," etc. These are followed by a triad which, it is stated, was much used in the middle ages, and again by one which, it is claimed, was a favorite in the Italian schools. Throughout the whole list of pairs and triads, good and bad, we fail to find a single case which it is not claimed embodies the results of artistic experience. It seems to us, then, that in this chapter the first and main aim has been the collection of "results with the view of establishing principles." Our author, then, having accepted without question these fruits of artistic labor, proceeds to analyze them for the purpose of ascertaining the principles that have been at work in their production. Among these, he finds helpful and harmful contrast, the desire to employ warm rather than cold color, etc. A less cautious writer than Professor Rood would probably have endeavored to construct a theory for practice based on the principles thus more or less established, but he attempts nothing of the kind. The facts and their suggested explanations are simply handed over to the student for his consideration. Thus the method pursued in this chapter by our author is precisely that which the writer in the "Nation" blames him for not following.

A word may here be added respecting the greater or less success with which this correct method has been executed. The critic in the "Nation" is apparently not aware that by far the larger part of the statements contained in the tables is taken not from Chevreul but from Brücke, and now for the first time appears in an English dress. This distinguished scientist states in the preface to his work ("Physiologie der Farben," Leipsic, 1866), that he is the son of a painter, has always been in constant intercourse with painters, and that from his youth he has studied optics in connection with its artistic applications. His statements with reference to the combination of the colors in pairs and triads he asserts embody the results furnished by artistic experience, and he adds that he has been unable to find any general rule which presides over the facts he has collected. These observations of Brücke are alluded to by Von Bezold, in the preface to his "Chromatics" ("Die Farbenlehre," 1874), as a great mass of delicate observations; and, from the fact that they are quoted by Professor Rood, we may also safely conclude that he has taken every pains to verify them as far as possible. As to what value they may ultimately be found to have for the artist and decorator, time alone can show, but for the present it will hardly answer to dismiss them contemptuously without study, particularly when we remember that they are not the fruits of scientific investigation, but of observation on artistic results.

We pass now to the second point made by this critic: Should the artist regard Chevreul's "laws of contrast"? The writer in the "Nation" thinks that our author would say "Ay," but he declares that most artists would say "No." Now, the laws of contrast simply express in a condensed form the effects that colored surfaces experience owing to the presence of other colored surfaces; it seems to us that to this question there can be only one reply, viz., that, consciously or unconsciously, artists always have and always will respect them; a delicate obedience to these laws in their most subtile applications constituting, indeed, one of the great merits of an accomplished colorist. Concerning this matter of contrast Ruskin well remarks: "Every hue throughout your work is altered by every touch that you add in other places; so that what was warm a minute ago becomes cold when you have put a hotter color in another place."* The so-called laws of contrast simply point out the nature of these subtile changes. The merit of a colorist is not that he formally follows these laws, but that consciously or unconsciously he is so completely permeated with them in all their varied applications, that they have become a part of himself, enabling him to apply them to complicated cases with a delicate certainty which often appears magical. We are surprised that the critic who assumes to know so much about artists should ask the question, "Ought the artist to regard the laws of contrast?" Established laws can never be disregarded with impunity by any class of men; they are self-executing.

* "Elements of Drawing," p. 196.

LITERARY NOTICES.

Gray's Botanical Text-Book. Sixth Edition. Part I. Structural Botany, or Organography on the Basis of Morphology. To which are added the Principles of Taxonomy and Phytography, and a Glossary of Botanical Terms. By Asa Gray, LL. D., etc., Fisher Professor of Natural History (Botany) in Harvard University. New York: Ivison, Blakeman, Taylor & Co. 1879. Large 8vo. Pp. 442. Price, $2.50.

This is the first volume of what, in the end, is to be a full botanical course of study. Part II., by Professor Goodale, will treat of physiological botany. Part III., by Professor Harlow, will be an introduction to cryptogamic botany; and Part IV., which Professor Gray hopes to accomplish himself, will contain a sketch of the natural orders of phænogamous plants, and of their special morphology, classification, distribution, products, etc.

The title-page of this important installment of the sixth edition will be made more intelligible to the general reader by the following extract from its introduction: "*Structural botany* comprehends all inquiries into the parts and the organic composition of vegetables. This is termed *organography* when it considers the organs or obvious parts of which plants are made up, and *morphology* when the study proceeds on the idea of type." By *taxonomy* is meant "the principles of classification," and by *phytography* "the rules and methods of describing plants." In the opening paragraph of Chapter I. it is further explained that *morphology*, the doctrine of forms, as the name denotes, is used in natural history in nearly the same sense as the older term comparative anatomy. If it were concerned merely with the description and classification of shapes and modifications, it would amount to little more than glossology and organography. But it deals with these from a peculiar point of view, and under the idea of unity of plan or type.

The first edition of Gray's "Text-Book of Botany" was published in 1842, in one moderate-sized octavo volume. The four subsequent editions were each a little enlarged from its predecessor; but, until now, one volume has sufficed for the treatment of the entire field of botanical science. When it appeared, botany was not generally studied in our schools. The analysis of flowers by the Linnæan system was fashionable in girls' seminaries, where there was a pretense of studying plants themselves; but it resulted in the merest pedantry. The system of classification was artificial; it did not appeal to the rational faculties, as did natural philosophy and chemistry; and sensible boys and girls repudiated the subject. To give it rank, it had to be placed on a new basis, and Gray's "Text-Book" accomplished this by the masterly way in which he presented the life-history of plants. The structure and development of cells was clearly set forth, the natural system of classification was adopted, and the study became both rational and attractive.

But other changes besides increase of size have taken place in this text-book. In the old editions, structural and physiological botany were considered together. There was no attempt to deal with them separately. But the present volume is specially devoted to *structural* botany, and leaves out physiology as far as possible. This difference is really greater than at first appears. Although structural botany was given along with physiology in the old editions, yet *physiology* was the only division of the science that was really learned from its pages. Of course, this was not intended by the author; but, with the human mind what it is, and the public schools such as they are, no other result was possible. When this work first appeared, and for long years thereafter, studying objects was undreamed of in our schools; lesson-learning was their sole occupation. But a descriptive science can not be learned from the pages of a book. Physiology *could* be acquired by the prevailing method, since it takes little account of the differences among plants, and would be much the same if the vegetable world consisted of only one species. The impression made upon pupils by the descriptive portions of "Gray's Class-Book" was so slight that, to the average student, the *science of botany* and the *physiology* of plants were about the same thing.

And so it happened that class after class of our youth left school complacently thinking that they knew botany, but with only the merest book-smattering concerning the classification of plants. Of course, if the forms and modifications of the organs of plants were not regarded, there could be little occasion for glossology; and, by the neglect of both organography and glossology, the sketch of the natural orders at the end of the volume was unintelligible. This could only be understood when the actual features of a large variety of plants were familiar to the mind, and the memory was also furnished with the exact terms applied to them. Educationally considered, therefore, this chapter of illustrations of the natural orders, covering more than a hundred pages, was little better than waste-paper.

The order of publication now adopted, which presents structural botany by itself at the outset of the study, will compel the teachers of botany to change their practice, and make the study of plants by direct observation a serious business. For, interesting and fundamental as is the physiology of plants, the discoveries of the last twenty years have rendered their morphological study more captivating still, so that the interest of the science reaches its highest point in systematic botany, or classification on the basis of genetic relationship. But the only possible admission to this delightful portion of the subject is through such a genuine knowledge of the contents of the present work as will come from wide and careful observation of living vegetable forms.

Another noticeable change in this treatise is the substitution of the doctrine of the development of species by natural selection for that of the special creation of species, which was taught in all former editions. The fifth was published in 1857, and Darwin's work on the "Origin of Species" did not appear until 1859. The new direction given to inquiry in natural history by this work, and the copious literature of the subject which followed it, have profoundly altered the aspects of biological science. The old system of comparative anatomy, which was based upon the doctrine of special creations, has given place to the modern science of morphology; which, from being, before Darwin's time, merely a descriptive study of forms, has become an analytical science of form, pervaded throughout by the principle of descent with variation. The following extract from his chapter on "The Principles of Classification" will sufficiently indicate the present attitude of Professor Gray toward the question of the evolution of species:

> The theory of descent, that is, of the diversification of the species of a genus through variation in the lapse of time, affords the only natural explanation of their likeness which has yet been conceived. The alternative supposition, that all the existing species and forms were originally created as they are, and have come down essentially unchanged from the beginning, offers no explanation of the likeness, and even assumes that there is no scientific explanation of it. The hypothesis that the species of a genus have become what they are by diversification through variation is a very old one in botany, and has from time to time been put forward. But, until recently, it has had little influence upon the science, because no clear idea had been formed of any natural process which might lead to such result. Doubtless, if variation, such as botanists have to recognize within

the species, be assumed as equally or even more operative through long anterior periods, this would account for the diversification of an original species of a genus into several or many forms as different as those we recognize as species. But this would not account for the limitation of species, which is the usual characteristic, and is an essential part of the idea of species. Just this is accounted for by *natural selection*. This now familiar term, proposed by Darwin, was suggested by the operations of breeders in the development and fixation of races for man's use or fancy—breeding in each generation those individuals only in which the desired points are apparent and predominant; in the seed-bed, by rigidly destroying all plants which do not show some desirable variation, breeding in and in from these with strict selection of the most variant form in the particular line or lines, until it becomes fixed by heredity, and as different from the primal stock as the conditions of the case allow. In nature, the analogous selection, through innumerable generations of the exceedingly small percentage of individuals (as ova or seeds) which ordinarily are to survive and propagate, is made by competition for food or room, the attacks of animals, the vicissitudes of climates, and, in fine, by all the manifold conditions to which they are exposed. In the *struggle for life* to which they are thus inevitably exposed, only the individuals best adapted to the circumstances can survive to maturity and propagate their like. This *survival of the fittest*, metaphorically expressed by the phrase natural selection, is, in fact, the destruction of all weaker competitors, or of all which, however they might be favored by other conditions, are not the most favored under the actual circumstances. But seedlings, varying, some in one direction and some in another. are thereby adapted to different conditions, some to one kind of soil and exposure, some to another, thus lessening the competition between the two most divergent forms, and favoring their preservation and further separation, while the intermediate forms perish. Thus an ancestral type would become diversified into races and species. Earlier variation, under terrestrial changes and vicissitudes, prolonged and various in geological times since the appearance of the main types of vegetation, and the attendant extinctions, are held to account for genera, tribes, orders, etc., and to explain their actual affinities. Affinity under this view is consanguinity; and classification, so far as it is natural, expresses real relationship. Classes, orders, tribes, etc., are the earlier or main and successful branches of the genealogical tree, genera are later branches, species the latest definitely developed ramifications, varieties the developing buds. Briefly: Taken as a working hypothesis, the doctrine of the derivation of species serves well for the coordination of all the facts in botany, and affords a probable and reasonable answer to a long series of questions which, without it, are totally unanswerable. It is supported by vegetable paleontology. which assures us that the plants of the later geological periods are the ancestors of the actual flora of the world. In accordance with it we may explain in a good degree the present distribution of species and other groups over the world. It explains, by inheritance, the existence of functionless parts, throws light upon the anomalies of parasitic plants, and, indeed, illuminates the whole field of morphology with which this volume has been occupied.

In looking through Part I. we are struck by the many new illustrations, and the new headings of pages and sections, all bearing witness to the recent rapid growth of morphological science. There is an entire section of nearly thirty pages given to the subject of "Adaptations for Intercrossing"—a subject the interest in which began in 1862, with the publication of Darwin's book on the fertilization of orchids by the aid of insects.

But, important and interesting as is the volume before us, and rejoicing as we do in the promise of those to come, we are chiefly glad that Professor Gray has proceeded upon the method of putting structural botany first in this elaborate course of study. It is now possible in some of the schools to study living plants, and this arrangement is an assurance that students of Gray's Botany will rationally pursue the subject of classification.

A Treatise on Hygiene and Public Health. Edited by Albert Buck, M. D. In Two Volumes. Illustrated. New York: William Wood & Co. Pp. 1450. Price, —.

There is something ludicrous and pitiable in the estimates which men form of the relative importance of different subjects of thought. It seems to be still the law that the popular solicitudes are in inverse ratio to the vital usefulness of the questions to which they are directed. Men lash themselves into furious excitement over the differences between tweedledum and tweedledee in politics, while they can be aroused to only a languid and careless attention to the life-and-death interests of daily family life. Say what we will, the next great subject in order in the development of civilization is that of hygiene. To use this world rightly, and get the most out of it, health is the first condition, and there is no interest so important both to the individual and to the community as its promotion and preservation. But to accomplish these objects knowledge is necessary. Valuable and trustworthy information upon hygienic topics such as can be followed with confidence to beneficent results has been but slowly acquired, and is yet far from perfect; but enough has been accumulated to work a sanitary revolution in society if reduced to general application. Of course, in matters of personal hygiene everything depends upon individual knowledge, and the disposition to use it; but the efficiency of measures for the promotion of public health is hardly less dependent upon popular intelligence. Needful sanitary laws may be passed, but the essential thing, after all, is that they shall be faithfully and vigorously carried out and not remain dead letters in the statute-book. This must depend upon the degree to which the people are instructed in hygienic subjects and are alive to the care of health. Hygiene has grown in recent years into an important branch of study, with a copious literature of monographs and manuals. Cyclopædias have been attempted, but they have hitherto been hastily compiled and are altogether inadequate for their purposes. We can, however, no longer complain of the want of a comprehensive and authoritative treatise upon this many-sided subject. The work before us covers the full ground, is thoroughly digested, and constitutes of itself a tolerably complete hygienic library.

This elaborate work seems to have had the following origin: In reproducing Ziemssen's "Cyclopædia of Practical Medicine" from the German, the editors and publishers found that the first volume, relating to the subject of public health, had been prepared so entirely from the German standpoint, and took cognizance of a state of things so materially different from that which exists in this country, that it was considered advisable to omit it in the American edition. But as the subject was of fundamental importance, it was felt that this omission must be repaired, by taking up the subject with special reference to the different climates, conditions of soil, habitations, modes of life, and laws of the United States. In this way the deficiency of Ziemssen's "Cyclopædia" would be amply repaired, so that its subscribers might possess the work in its completeness, while the hygienic volumes would be of interest to physicians generally, and also to the educated classes, who are acquiring a growing interest in the subject.

The introduction by Dr. John S. Billings, besides prefatory explanations, treats of the causes of disease and the jurisprudence of hygiene. After considering the various definitions of hygiene, and showing how its meaning may be so extended as to sweep in immense tracts of human knowledge, Dr. Billings says: "The hygiene of which this volume is to treat has not so broad a scope as that just hinted at, since the intention has been to produce a practical treatise limited to a consideration of the most usual preventable causes of disease in civilized countries, and more especially in the United States, and of the surest and most economical means of diminishing or destroying these causes."

The following remarks are still further illustrative of the ideas involved in the scheme of this work: "To what extent the prevention of disease, the prolongation of life, and the improvement of the physical and mental powers in man may be carried, we do not know; but no doubt the tendency of those who write and speak most on this subject is to exaggerate the possibilities of improvement; since it does not seem probable that the conditions of perfect personal and public health are attainable, except in rare and isolated cases, and for comparatively short periods of time; yet 'that the average length of human life may be very much extended, and its physical power greatly augmented; that in every year within this Commonwealth thousands of lives are lost which might have been saved; that tens of thousands of cases of sickness occur which might have been prevented; that a vast amount of unnecessarily impaired health and physical debility exists among those not confined by sickness; that these preventable evils require an enormous expenditure and loss of money, and impose upon the people unnumbered and immeasurable calamities, pecuniary, social, physical, mental, and moral, which might be avoided; and that means exist within our reach for their mitigation or removal; and that measures for prevention will effect more than remedies for the cure of disease'—will probably be admitted by every one who has carefully studied the subject and made himself familiar with what has been accomplished in certain limited localities."

It will not be possible in our space to go into any analysis of the varied and extensive contents of this treatise, much less to attempt a criticism of its plan or execution. It has evidently been done with admirable judgment, and the names of its contributors are a sufficient guarantee that its pages faithfully reflect the present state of hygienic knowledge. Part I. of the first volume is devoted to individual hygiene, and begins with the treatment of "Infant Hygiene," by Dr. A. Jacobi, of New York. This is followed by "Food and Drink," by Dr. James Tyson, of Philadelphia. Professor William Ripley Nichols, of Boston, writes "On Drinking Water, and Public Water Supplies." The article on "Physical Exercise" is by Dr. A. Brayton Ball, of New York; and the last essay of Part I. is on "The Care of the Person," by Dr. Arthur Van Harlingen, of Philadelphia. Part II. of Volume I. treats of "Habitations," and its first essay is on "Soil and Water," by Dr. William H. Ford, of Philadelphia. Dr. D. F. Lincoln, of Boston, next takes up "The Atmosphere," and Dr. Francis H. Brown, of Boston, closes Volume I. by a disquisition on the "General Principles of Hospital Construction." Part I. of Volume II. treats of "Occupation." The first essay is on the "Hygiene of Occupation," by Roger S. Tracey, M. D., of New York. Charles Smart, M. D., C. M., assistant Surgeon U. S. Army, takes up the "Hygiene of Camps"; and Dr. Thomas J. Turner, Medical Director U. S. Navy, treats of "Hygiene of the Naval and Merchant Marine." Henry C. Sheafer writes on the "Hygiene of Coal Mines," and Rossiter W. Raymond, New York, contributes an essay on "The Hygiene of Metal Mines." Part II. of Volume II. is devoted to the general subject of "Public Health." Dr. Thomas B. Curtis, of Boston, presents the subjects of "Infant Mortality" and "Vital Statistics"; Professor Stephen P. Sharples, of Boston, considers "Adulteration of Food"; and Dr. Roger S. Tracy develops the subject of "Public Nuisances." "Quarantine," with reference to seaport towns, is by Dr. Vanderpoel, of New York; and Dr. S. S. Herrick, of Louisiana, writes on "Inland Quarantine." "Small-pox and other Contagious Diseases" are treated by Drs. Hamilton and Emmett, of New York, and "The Hygiene of Syphilis" by Dr. F. R. Sturges, of New York. "Disinfectants" is by Dr. Elwyn Waller, of New York; "Village Sanitary Associations" is by Dr. R. S. Tracy; and Dr. Lincoln, of Boston, closes the work by an essay on "School Hygiene."

The treatise has an excellent index, and a very valuable feature of it is the copious bibliography appended to each contribution.

First Lines of Therapeutics: As based on the Modes and the Processes of Healing as occurring spontaneously in Disease; and on the Modes and Processes of Dying as resulting naturally from Disease. In a Series of Lectures. By Alexander Harvey, M. A., M. D., Edinburgh, Emeritus Professor of Materia Medica in the University of Aberdeen; Lecturer on the Practice of Medicine, etc. New York: D. Appleton & Co. Pp. 278. Price, —.

This important work is addressed to a fundamental question in practical medicine —the old question of the relations subsisting between nature and art in the cure of disease—what is the value to be assigned to the *vis medicatrix naturæ*, or the spontaneous processes of healing and recovery in the diseased constitution? That the followers of the medical art should magnify their vocation, and that practitioners should be led to favor those theories which enlarge the sphere of practice, is perfectly natural, but there can be no doubt that the consequence is greatly to exaggerate the efficacy of drugs in the treatment of disease. The doctors want business, and the people want medicine; and so the profession is at any rate not pecuniarily interested in belittling the administration of remedies. But able physicians have appeared from time to time who recognized very clearly that there is far too much medical meddling, and too little recognition of the forces and tendencies of nature in the eradication of disease. It is to the credit of the profession that its best mind is in cordial sympathy with all rational hygienic measures which have for their object the prevention of disease; but the use of hygienic agencies *in disease* is a lesson which many think has yet to be more enforced in the sphere of medical practice.

Many medical men have ranged themselves on the side of this question represented by Dr. Harvey in the present volume, prominent among whom have been Alison Gubler and Sir John Forbes—the latter author, indeed, having carried his views so far as to be ranked as a therapeutic *nihilist*. But it is difficult to take up a position strongly without being charged with exaggeration and exclusiveness. Dr. Harvey, at any rate, is not open to the charge of extreme partisanship, and has done an excellent service to his profession by this digest of information from wide sources, and the analysis which he has made of the nature of the curative powers of the organism, and the quality of disease; and while he strongly asserts the supremacy of nature over art, he yet gives to art that which is fairly its due. The final chapters of the work, on the "Physiology of the Several Processes of Dying," are of especial interest.

The author publishes an extract from a letter written him by Sir Thomas Watson, author of the well-known "Principles and Practice of Physic," a portion of which we here append. Dr. Watson says: "You have thoroughly thrashed out the great theme which you proposed to discuss. It is certain that a sound system of therapeutics must rest on a consideration of what nature in many cases is capable, and in some fewer cases is incapable of doing in disease; and, on the other hand, on what art may do in helping or hindering nature. All this, I say, you have most fully explained; and I feel sure that the student of your volume can not fail to have his mind cleared up and settled on these most important subjects."

The reception of Spencer's "Data of Ethics" by critics generally has been most gratifying, and indicates a favorable change in the habits of these parties. Formerly they seem to have been chiefly anxious to put before the world their own views of Spencer's works; now they conclude it is better to let him speak for himself. This may somewhat belittle the function of the critical go-between, but it will be much more satisfactory to both the author and the public, besides the incidental advantage of getting more truth into circulation. A large number of the reviews of the "Ethics" have consisted of able and discriminating summaries of Spencer's doctrines; and even Professor Bain, whose position certainly entitles him to assume the function of judge, is chiefly concerned to get Spencer's opinions fully and fairly before his readers. We reprint his article because of its authority in this branch of thought.

Mr. Spencer has resumed labor upon the "Principles of Sociology," and will shortly publish that part of Vol. II. which treats of the "Development of Ceremonial Institutions." This is a most interesting subject, and becomes very attractive in Spencer's hands. This will be followed by the "Development of Political Institutions," one of the most important parts of his philosophical undertaking.

Neurility: Correlated Converted Physical Forces. By S. V. Clevenger, M. D. Pp. 24.

The point which the author aims to establish in this essay, if we rightly understand him, is that physical energy is sufficient for the production of all the phenomena of life without the intervention of a so-called "vital" force; and that the nervous system is capable of holding in its substance all forms of physical energy which by means of "cells and ganglia may be interchanged into different higher and lower forms or held as originally absorbed."

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Seeing and Thinking. By the late W. K. Clifford. Same publishers. 1879. Pp. 156. $1.

First Book of Qualitative Chemistry. By A. B. Prescott. New York: D. Van Nostrand. 1879. Pp. 160. $1.50.

Ice-making Machines. By M. Ledoux. Same publisher. 1879. Pp. 150. 50 cents.

The Origin of Fever. By R. T. Colburn. Rochester, New York: Andrews print. 1879. Pp. 26.

Memoirs of the Science Department of the Tokio University. Vol. I., Part I. Shell Mounds of Omori. By E. S. Morse. Tokio: The University 2539 (1879). Pp. 36, with 18 Plates.

Der Irrthum des Speciesbegriffes. Von Dr. Otto Kuntze (Verhandl. d. Leipz. geogr. Ges. 1879). Pp. 18. Verwandtschaft von algen mit Phanerogamen. Von dem selben (Aus "Flora." 1879). Pp. 22.

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Lithophane and New Noctuidæ. By A. R. Grote. From "Bulletin U. S. Geological Survey." Pp. 8.

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The Magic of the Middle Ages. By Viktor Rydberg. Translated from the Swedish by August Hjalmar Edgren. New York: Henry Holt & Co. 1879. Pp. 231. $1.75.

Notes on Railroad Accidents. By Charles Francis Adams, Jr. New York: G. P. Putnam's Sons. 1879. Pp. 280. $1.25.

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

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POPULAR MISCELLANY.

Physiology of the Turkish Bath.—Most accounts of the Turkish bath have been confined to general descriptions of the details of the process, and of the sensations experienced during its use; while comparatively little attention has until lately been paid to the more important consideration of its influence on the bodily functions. To supply this need, Mr. William James Fleming, M. B., Lecturer on Physiology in Glasgow, began some years since a series of careful experiments with the action of the bath on his own person. These were continued down to a recent period, and we now have the results of the investigation in the form of a valuable paper published in vol. xiii. of the "Journal of Anatomy and Physiology."

To those not acquainted with this form of bath it will be sufficient to say that the essential part of the process consists in the immersion of the body in dry air at a temperature varying from 130° to 200° Fahr. for from half an hour to an hour generally, and subsequent douching with cold water.

Mr. Fleming's experiments were all made between lunch and dinner, usually from 4 to 6 P. M., in a bath heated by Constantine's system. This is an arrangement of stoves by which a constant current of pure air is drawn from the outside atmosphere, heated by passing through a species of oven, and driven into one of the apartments of the bath with such force that it traverses the whole suite of rooms, parting with some of its heat in each, and ultimately escaping from the last into the outer air again. By this means not only the air for breathing but also that in contact with the skin is constantly renewed, so that a layer of watery vapor does not, as in all baths heated with stationary air, soon cover the body, and thus convert the bath into a vapor one. The experiments usually began with a heat of about 170° Fahr. for a few minutes, in order to produce sweating rapidly, followed by a temperature of about 130° Fahr. during the remainder of the stay in the hot rooms. This the author regards as the best practice for habitual bathers, as perspiration, being once freely established in the hottest room, is kept active by the lower degree of heat.

The investigation was specially directed to the effect produced by immersion in hot, dry air on—1. The amount of material eliminated from the body in excess of the normal; 2. The alteration produced in the temperature of the body; 3. The influence on the pulse-rate; 4. The influence on the rate of breathing; 5. The alteration in the composition of the urine; 6. The composition of the sweat; and, 7. The arterial tension as shown by the sphygmograph. The results of the investigation are presented in the form of averages representing a large number of observations.

Omitting a description of the manner in which the experiments were conducted, and also the detailed results obtained, the following are the conclusions drawn by the author from those results. It was shown—1. That a very large quantity of material can be eliminated from the body in a comparatively short time by immersion in hot, dry air; and, although the greater part of this is water, still solids are present in quantity sufficient to render this a valuable emunctory process; 2. The temperature of the body and the pulse-rate are markedly raised. The respiration falls at first, but afterward is less influenced than would be expected. The urine is increased in density, and deprived of a large portion of its chlorides, while, if anything, an increase in the amount of urea is produced. Arterial tension is increased, due probably to the rapid action of the heart and the gorged condition of the capillary circulation.

From these the following practical considerations as to the use of the Turkish bath in medicine are deduced: Its most important effect is the stimulation of the emunctory action of the skin. By this means we are enabled to wash as it were the solid and fluid tissues, and especially the blood and skin, by passing water through them from within outward to the surface of the body. Hence, in practice, one of the most essential requisites is copious draughts of water during the sweating.

The elevation of the temperature, and more especially of the pulse-rate and blood-pressure, point to the necessity of caution in cases where the circulatory system is diseased.

Excessively long duration of the bath seems to produce more or less depression, as shown by the fall of the pulse and temperature after fifty-five minutes.

The great advantage of the bath seems to be the power it gives of producing a free action of the skin in persons of sedentary habit, or suffering from disease interfering with fluid excretion, and by its means probably a considerable elimination of morbid matter may also be brought about. Besides, and along with this, it is an efficient means, if resorted to sufficiently early, of relieving internal congestion.

Distribution of the Electric Light.—A recent trial, in San Francisco, of Molera's and Cebrian's system of dividing and distributing the electric light, is thus described in the San Francisco "Morning Call" of September 30th: "An exhibition of a new system of utilizing and dividing the electric light, recently discovered by Messrs. Molera and Cebrian, civil engineers, of this city, was given last night at 412 Market Street. Quite a crowd of spectators witnessed the experiments, which had a very satisfactory result. Two floors were well and uniformly lighted by the light obtained from a generator placed in one corner of the upper story of the building. The manner of thus dividing the electrical current consists of the use of a system of reflecting mirrors and lenses, which concentrate and conduct the parallel rays or beams of light by the medium of tubes to any desired distance without weakening, except in a comparatively small degree, its intensity. The main advantages claimed by the inventors for this system are, that the light may, through the agency of a diffusing lens, be distributed from a single beam throughout all the rooms of a house or hotel, and may be divided without material loss of power. The supply of light is also controlled by the reflector, and in any or all of the rooms the brilliancy of the light may be increased or diminished at will. It is further argued that the system dispenses with the necessity for regulators or lamps, that the loss consequent upon the use of electrical conductors is avoided, and that the capital invested is smaller than is required for gas-works. Heretofore the difficulty experienced by electricians has been to divide the light without weakening in too large a degree its power. Should the system of Messrs. Molera and Cebrian prove a practical success, it may be economically used in lighting not only private residences and public institutions, but even whole cities."

Color-Blindness of Seamen.—An article on color-blindness, in a late number of the "English Mechanic," quotes some very important facts from the records of the British Board of Trade, derived from examinations of seamen applying for "mate's" or "master's" certificates, concerning their ability to distinguish colors. We select a few from the many instances of color-blindness detected by these examinations. One seaman, a candidate for a second master's certificate, described green glass as "dark red"; in another case a green card was called "yellow"; and a man who had been over eighteen years at sea was reported as quite unable to distinguish any of the colors. Another who had been more than seven years at sea described the red glass by daylight as "green," the dark green as "red," and the yellow as "red"; while by gaslight he named the light blue "green," the dark green "red," and the yellow "red." This appears to be a case of Daltonism, or incapability of perceiving the red end of the spectrum. There are several similar instances which differ only in details; but perhaps the most interesting case is that of a candidate for a second mate's certificate who had served nearly five years at sea—a case that ought to have been sent to a court of appeal. By daylight he described the red card as "green," the yellow and green glasses "red," and the red glass as "dark green." By artificial light he called the yellow and green glasses "red," and the white glass "dark green." This man obtained a certificate from the London Ophthalmic Hospital testifying that he was not color-blind, but on reëxamination he still described dark green as "red," light green as "neutral," and yellow as "red" by artificial light, while by daylight he called the green glasses "red" once and "yellow" once. This last difference may have been caused by the manner in which the question was put, and ignorance of the names of colors. In view of these facts, the query suggests itself, may not the recent dreadful accident to the steamer Champion have been due to the inability of the lookout to distinguish the lights on the other ship, which was discovered only when near enough to take in her general outline?

Apprentice-Schools in France.—This is the title of a highly suggestive paper on the subject of science teaching in the public schools, read by Professor S. P. Thompson at the last meeting of the British Association. As the subject is daily acquiring new importance in this country, we present a pretty full abstract of the paper as it appeared in "Nature." The problem to be solved, in the author's opinion, is, how to give that technical training and scientific knowledge to artisan children which their occupation demanded, without detaining them so long at their schooling as to create a distaste for manual labor. There were four solutions of the problem, all of which had been tried, and illustrations of which could be seen in Paris. They were: 1. Send the children to work in the factory or workshop at an earlier age, making it obligatory all through their apprenticeship that they should have every day a certain number of hours' schooling in a school in the workshop or attached to it; 2. Keep the children at school as long as their education was unfinished, but set up a workshop in the school, where they should pass a certain amount of time every day so as to gain at least an aptitude for manual labor; 3. Organize a school and a workshop side by side and coördinate the hours given to study with an equal number of hours devoted to systematic manual labor; and, 4. Send the children half the day to the existing schools, and the other half to work half-time in the workshop or factory. Schools of the first type had existed in France for nearly thirty years, and at the close of 1878 there were no fewer than 237 schools of this character. So far as he was aware, there was only one school of the second type—the Ecole communale d'Apprentis, in the Rue Tournefort, Paris. The peculiarity of this school was that workshop training was being given to lads who had not yet completed a course of elementary education. Of the third type some admirable examples were to be seen in Paris. Some very interesting particulars were given of the progress of the horological school at Besançon. The fourth type or half-time school, which was English in its origin, was rarely to be found in France. Since the old apprenticeship had virtually lapsed, there was nothing to save the young artisan of the rising generation from degenerating into a mere machine, unless a new agency could be practically organized. What was claimed for the apprenticeship school was that its pupils do not possess just a bare minimum of knowledge sufficient to procure them means of subsistence in one narrow department of one restricted industry, but that they possess both manual dexterity and a fair technical knowledge which would enable them not only to earn more and to turn out better work, but also to be less at the mercy of the fluctuation of trade for the means of subsistence. Besides the new apprenticeship being better for real instruction in technical principles, it was also better for practical work in so far as it shortened the needlessly long years of the apprenticeship, and imparted at an earlier age all the manual capacity that apprenticeship in any form could impart. There were not wanting on our horizon signs of significance in the problem of the relation of science to labor. We had really skilled workmen, and no foreign workmen were their equals, but they were only units in a crowd. Take which view they would, technical education, and, above all, the technical education of the artisan classes, was a *sine qua non* of the future industrial prosperity of Great Britain. What steps, then, must be taken to give effect to the new apprenticeship? Two things would determine the success or failure of the school: 1. The obtaining of the right kind of teachers; and, 2. The adoption of a system of instruction based upon drawing, which was the language of the manufactures, the handicrafts, the constructive industries of all kinds. It was evident that the first step would be the foundation of a system for training competent teachers. Then there must be a central technical college, for through such an institution alone could community of thought and method of work be obtained.

Two Remarkable Epidemics.—In the spring of 1878 an epidemic of typhoid fever broke out at Zurich, Switzerland, which possesses peculiar interest. A musical festival was held in that town in May, and out of the seven hundred persons who attended it five hundred were attacked by typhoid fever, of whom one hundred died. A minute inquiry into the circumstances left but little doubt that the epidemic was due to the use of bad veal furnished by an innkeeper of the place. It may be claimed by those who attribute to general causes the power of originating specific diseases that the typhoid fever was due to a septic poison present in the veal, depending possibly on a beginning fermentation, which was not destroyed by the cooking to which it had been submitted. On the other hand, as the animal from which the meat was taken was sick, it may be asked whether it might not have been suffering from typhoid fever, although this disease has never yet been recognized among animals. It is a remarkable fact that in 1839 a similar but much less fatal epidemic occurred in a neighboring locality. After a reunion that took place under similar circumstances, four hundred and forty persons were taken sick with all the symptoms of typhoid fever. It is probable that in this case also the meat of a sick calf gave rise to the disease.

South-African Cannibals.—At the late meeting of the British Association, the French explorer Brazza read a paper on "The Native Races of the Gaboon and Ogowai." A preceding speaker, Major Serpa Pinto, had spoken of races having European characteristics inhabiting the region about the headwaters of the Zambesi. M. de Brazza was of opinion that these people had come from the north of Africa, because, under the name of Ubamba, he had found races very much resembling them to the south of the Congo. The negroes Pinto saw were probably the advance-guard of an invasion which had overrun the country to the east of the Gaboon. Stanley spoke of a great emigration very much resembling what had taken place among the Fan cannibals. There had been much talk indulged in adverse to the cannibal races of this part of Africa. Du Chaillu, who had visited for one day only one of the Fan villages, had given a description of this race, which had been too much influenced by accounts he had received from a tribe at war with the cannibals. He had said that in their villages he had found quarters of human flesh exposed for sale; that they killed and ate their prisoners of war, and that they sold the bodies of their own dead who had died of disease to their neighbors. M. de Brazza denied the truth of such accounts. As a proof that the Fans had kindly and generous sentiments, he told how a Fan chief had been kind to him when he was obliged to leave his people sick in the bush. He owed his life to the Fan chief, and he should always be grateful to him and his people. He wished, therefore, to do all he could to remove the prejudice against the Fans which had been excited by Du Chaillu. They were a very generous, courageous people. It was true they were cannibals—that they ate their prisoners of war; but it was with them a religious idea, for they believed that in eating the heart of a brave man the courage of the dead passed into themselves. M. de Brazza also gave an interesting sketch of the Akkas, a dwarf race he found scattered up and down among the different peoples, like what the Jews or the gypsies were in Europe. The height of the Akkas was from three to four feet.

Raising Sunken Vessels.—In the Plötzen Lake, which is not far from Berlin, and the depth of which is very considerable, reaching in some parts to twenty-eight metres, an interesting attempt has been made to raise sunken vessels. The method, which is the invention of Herr Eidner, a Vienna civil engineer, consists in applying carbonic acid in the following manner: In an empty balloon a bottle half filled with sulphuric acid, surrounded with Bullrich's salt, is fixed; the bottle is destroyed by turning a screw, and the two substances mix and produce carbonic acid, which fills the balloon. It is obvious that, when this apparatus is brought into operation in the hull of a sunken ship, the effect must be, if a sufficient number of balloons are filled, to raise the vessel. In the experiments on the Plötzen Lake, a small vessel or boat weighing several hundred-weight, was first sunk. A diver then went down with the necessary apparatus, which he set in operation in the interior of the ship. Hardly had he done so before the vessel began to rise to the surface, where it was maintained by the balloon. In a second experiment five heavy sacks filled with sand were thrown overboard, in a part of the lake which was sixteen metres deep. The diver descended, fastened all the sacks together, and, fixing the balloon apparatus to them, set it going, with the effect that the whole of the sacks were brought up to the surface.

Petroleum in Iron-making. — The successful employment of petroleum as a fuel in the manufacture of iron, has, according to the "Engineering and Mining Journal," been accomplished by a process invented by Dr. C. J. Eames, and now in practical operation at Titusville, Pennsylvania. The petroleum is vaporized by means of highly heated steam, thrown into a chamber in which the oil is caused to trickle over a series of horizontal shelves; and the mixture is then driven onward to the combustion-chamber, where it is ignited and forced into the furnaces by the air-blasts which it encounters at this point. "The evident advantages," says the "Engineering and Mining Journal," "of petroleum-fuel, are the perfect control under which the heat is held; the extremely high calorific intensity of this 'water-gas'; and the freedom of the fuel from any elements injurious to the iron. It is claimed that the work can be performed much quicker, and the quality of the product can be made much more uniform and of higher grade, than can be secured with coal-fuel."

NOTES.

According to Professor Lintner, President of the Entomological Club, the study of entomology is making very gratifying progress in this country; collections are multiplying, and the literature of the subject is growing rapidly. The Club has compiled a list of persons engaged in the study of entomology in the United States; it already contains eight hundred and thirty-five names.

Dr. Krümmel, of Göttingen, estimates the mean depth of the sea at 1,877 fathoms, and then makes a comparison of the volume of the land above sea-level with the volume of the sea. Accepting Leipoldt's estimate of the mean height of Europe, viz., 300 metres, and estimating the mean heights of Asia and Africa, of America and Australia, to be 500, 330, 250 metres respectively, Dr. Krümmel obtains the mean of 420 metres or 0·0566 geographical mile. The surface ratio of land to water being considered as 1 to 2·75, the volume of all dry land above sea-level is inferred to be 140,-086 cubic miles, and the volume of the sea 3,138,000 cubic miles. Thus the ratio of the volumes of land and water is as 1 to 22·4. That is, the continents, so far as they are above sea-level, might be contained 22·4 times in the sea-basin. But reckoning the mass of solid land from the level of the sea-bottom, the former would be contained only 2·443 times in the sea-basin.

The circulation of scientific works in Russia is so small, that native men of science find it nearly impossible to get their labors published. Kovalevsky, according to the London "Examiner," left at his death no less than thirty works in MS.; he could find no publisher for them. Professor Vasilief, the eminent Orientalist, has several volumes on "Buddhism and Philology," which he is compelled to keep in his portfolio for want of means to publish them.

The "Gazette des Hôpitaux" records an extraordinary case of loss of hair from fright. A girl seventeen years of age one day narrowly escaped death by crushing, and was much frightened. For three days she suffered headache, chills, and itching of the scalp. The symptoms were then allayed, with the exception of the itching, which continued. On combing her hair, it came out in great quantities, and soon she was quite bald. This baldness was permanent.

Of the views adopted by modern chemists concerning the structure of the carbon compounds, Professor Ira Remsen holds that they are correctly based and fairly demonstrated, but that they are steps in a path where greater progress is yet to be attained. Some of them will no doubt be disproved, yet, like the search for the philosopher's stone, they will serve to advance chemical science.

The usual average of rainfall in England, as reckoned for the first six months of the year, is a fraction less than twelve inches. This year the fall from January to June—five months—was eighteen and a half inches. Again, in the first six months of 1878, according to observations made at Greenwich Observatory, there were six hundred and forty-three hours of sunshine. This year there were only four hundred and seventy-one hours of sunshine in the same time. June, 1878, was regarded as a gloomy month; but it had one hundred and eighty-one hours of sunshine, whereas June, 1879, had not quite one hundred and nineteen hours.

From experiments made by Arloing, it appears that chloral does not act as an anæsthetic on the sensitive-plant, while ether and chloroform have an effect upon it similar to that which they exert on animals. M. Arloing in his experiments caused the anæsthetics to be absorbed by the roots of the plant.

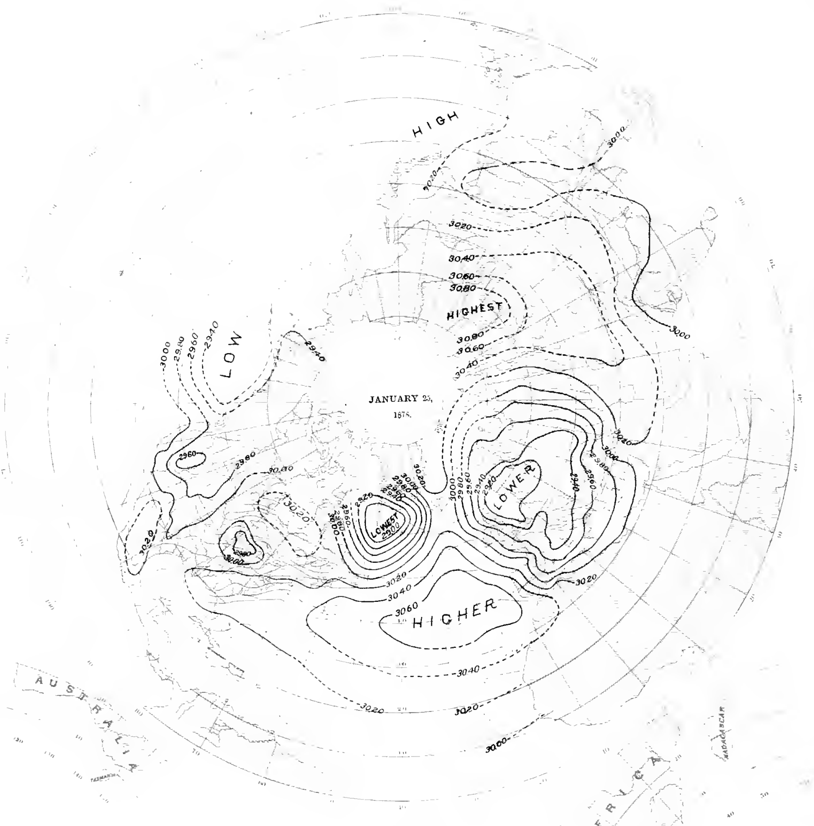
Near Stramberg, in Moravia, have been discovered certain caves which, in prehistoric times, were inhabited by man. The contents of these caves clearly prove the existence of man in very remote times—the age of the mammoth and the cave-bear. Thousands of bones have been found at the depth of two or three metres, representing mammoths, rhinoceroses, bears, horses, deer, reindeer, and with them well-preserved implements of stone and bone, objects in bronze, rings, needles, pottery, arrow-heads, and knives.

An exhibition was lately given in Paris of a method of employing electro-magnetism as a means of subduing vicious horses. With bits, bridles, nose-bands, and curbs specially constructed so as to apply a gentle current from a portable electro-magnet to the required place, seven particularly violent horses were reduced to obedience, and suffered themselves to be shod.

In the "Journal of the Asiatic Society of Bengal" is published an account of a very remarkable snowfall in Cashmere, which began in October, 1877, and continued almost uninterruptedly up to May, 1878, the general depth of the snow being then estimated at from thirty to forty feet. Houses and villages were crushed under the enormous weight, avalanches were frequent on the hillsides, and wild animals perished in great numbers.

Messrs. Martin and Tessier propose a mixture composed as follows for making uninflammable textile fabrics, paper, etc., viz.: Pure sulphate of ammonia eight parts by weight, carbonate of ammonia two and a half parts, boracic acid three parts, pure borax 1·7 part, starch two parts, water one hundred parts. The articles are to be steeped in the mixture (boiling) till they are thoroughly saturated; then they are dried and pressed.

The French Association for the Advancement of Science takes a surprising "new departure" next year by selecting Algiers as the place of its meeting in 1880. To avoid the inconveniences of the great heat of August, the meeting will be held in April.



Data, as appearing in the International Bulletin of similar date.
Isobars in *black* exhibit atmospheric pressure at sea-level and are charted from data as reported by the several observers.
Isotherms in *red* exhibit temperature of air, similarly charted.
Broken or dotted lines indicate that the lines so broken are doubtful.
Arrows, when charted, fly with the wind and exhibit wind direction and force.

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Albert J. Myer

BRIG. GEN. BVT. ASSG'D. CHIEF SIGNAL OFFICER, U. S. A.

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THE INTERNATIONAL WEATHER-SERVICE.

By Professor T. B. MAURY.

THE "weather" is that mystic word which sums up the physical influences most affecting the human frame for good or ill. The splendid, ever-varying panorama of the sky, the benign mutations of the seasons, the immense pulsations of the atmosphere furnished, however, for ages, themes for the poet rather than for the philosopher. In the presence of its tremendous though cloud-veiled forces, as the high priest of old on the entrance of the sanctuary, we tread with awed footstep. From time immemorial its phenomena have engaged the daily and deepest attention of men; and the ever-popular, ever-compulsory study of their changes, in the language of all civilized nations, has been called "meteorology," which literally means "the science of *the sublime*." "Distance and time," says the physical geographer Ansted, "seem annihilated when we watch the action of these mysterious influences, and we may almost recognize the reality of an existence unhampered by natural impediments when we find an instantaneous response of our innermost senses to a material stimulus applied within the burning atmosphere of the sun." But the overmastering interest and awe, awakened by the terrestrial atmosphere, through which this stimulus reaches us, are intensified by the consciousness that upon it we depend for vital breath, and that it is the medium through which an invisible hand sweeps every chord of humanity.

It is to that grand and systematic investigation of this physical agent, which has recently been commenced by the concert of the nations, in a system of world-wide "Simultaneous" observations, known as The International Weather-Service—to its history, methods, and utilities—we would now direct the reader's indulgent attention. Before doing so, however, it will be necessary to glance at the advances in weather-research that have led to this undertaking.

The exploration of the vast body of water which surrounds the land-masses of the globe has been, since the sixteenth century, rapidly prosecuted. Its configuration has been determined, its tides have been weighed, its gulf-streams and counter-currents gauged, and even its abyssal depths sounded and surveyed, until we can now hardly speak, save by poetic license, of "the dark, unfathomed caves of ocean." But the exploration of that other and almost boundless ocean of air which envelopes the whole earth and whose winds sweep its surface, swaying the waters of the sea and affecting every form of terrestrial life, has progressed but slowly. The upper atmosphere is pierced by but few of the earth's mountain-peaks upon which meteorological stations can be efficiently maintained, while the spasmodic attempts at aëronautic investigation of the cloud-land, daring as they have been, have realized less knowledge of its currents than that which Columbus in his voyages of discovery acquired of the circulation of the equatorial waters. Investigation has been, therefore, perforce restricted for the most part to the phenomena of storms, cyclones, and anti-cyclones, moving at the bottom of the great sea of air—phenomena involving such insignificant portions of the atmosphere, when compared with the superincumbent mass, that a leading meteorologist has hyperbolically likened them to ordinary "smoke-rings." Even in the lower atmospheric strata, the different national bands of observers have been widely separated—here and there an ocean unsentineled rolling between them—so that their collated reports conveyed no clearly connected account of the transcontinental movements of air; and it is to-day disputed by some that North American storms cross the Atlantic to western Europe. But, worse than all else, the observations taken by the most painstaking and indefatigable observers were, until recently, systematically vitiated, not only by a lack of uniformity in the methods, but by the more fatal lack of uniformity in the hours of observation. What would be thought of a little army confronting immense odds, some of whose regiments had one plan of battle and some another, some asleep when others were engaged, but none acting simultaneously? Yet, such is a fair representation of the world's observational force which was expected to attack the great problems of meteorology, as it was until less than a decade ago.

In 1870 the United States entered the field of weather-research; and, for the first time in the history of meteorology, there was then established a broad system of simultaneous observations and simultaneous reports of the weather. These reports were immediately worked up and graphically embodied in the simultaneous weather-maps, issued thrice daily from the office of the Chief Signal-Officer, U. S. A., General Albert J. Myer, whose original and announced plan was to observe the weather over the whole country "*at the same mo-*

ment of actual (not local) *time*," as was stated on every weather-map. This conception aimed at the rescue of meteorological researches from that disorder and disconnectedness which had always characterized the observational work. The prime object was to gain a daily *conspectus* of the atmosphere over the country as it *actually* was, and as it would be seen if a *photographic* view of it, so to speak, could be taken. The simultaneous method, when announced, seemed so natural and simple that one might have wondered that any other was ever attempted. Observations called "synchronous" had been, indeed, before this time, energetically made in several countries; but the term "synchronous" was used to signify that every observer read off his instruments at given hours of his own *local* time, and not at the same moment of physical time. Etymologically, there might be little or no difference between "synchronous" and "simultaneous," but, for all the purposes of atmospheric investigations over a vast territory like that of the United States, the practical difference was by no means insignificant. When observers, who on the old "synchronous" method reported the weather-status each at the same hour of local time, were separated by hundreds of miles, their reports failed to represent the actual fluctuations of the atmosphere and the true bearings of its cyclonic and anti-cyclonic movements; so that, when the meteorologist came to compare and chart the combined data, they yielded necessarily a distorted or untrue picture of the ever-restless aërial ocean. On the other hand, in the "*simultaneous*" method, since all the observers over the wide field of the research read their instruments at one and the same moment (7.35 A. M. Washington mean time), their reports, when charted, gave a true and life-like representation of the physical phenomena as they actually coexisted and conspired. As on the screen of the artist's camera the sun instantly paints the true image of the human face before its expression can be changed, so does the process of simultaneous observation seize and secure all the elements necessary to delineate the current physical features and conditions of the atmosphere, as existing at a *fixed* moment, and before they can have time to undergo change. Simple as this expedient is, it is evidently the key to all effective research in a vast gaseous ocean whose currents and waves are ceaselessly rolling and rapidly altering their geographical bearings, even while the sun is quickly passing from one meridian to another. Were all the weather observers of the world to read off their instruments as it were by a given tick of one clock, their collective data would furnish materials for the most exact delineations of the complex atmospheric machinery which it is possible to obtain. Instead of piling up a mass of weather bulletins unsuited for purposes of a rigidly scientific inter-comparison, as was so long done,* they would contribute

* In the old system of telegraphic weather-reports established by the Smithsonian Institution, the observers reported at 8 A. M., 2 P. M., and 9 P. M., each at his own *local* time. Accordingly, their reports could not give exact results. To take a not uncommon

solid and coherent facts of nature, all ready to be put together and worked up by the meteorologist into a noble and useful science.

Having noticed the first attempt ever made to establish a system of "Simultaneous weather-reports," and indicated the unique character of the system, as carried out by the United States since 1870, we hasten on to the history of its extension to the vast field of *international meteorology*. In September, 1873, the International Meteorological Congress was convened at Vienna, to consider all the graver questions that were then agitating public and private investigators, as to the progress of weather-science. The Congress was composed of official representatives, charged with the meteorological duties pertaining to the researches of their respective Governments. It was then proposed by the representative of the United States, General Myer, that "*it is desirable, with a view to their exchange, that at least one uniform observation, of such character as to be suited for the preparation of synoptic charts, be taken and recorded daily and simultaneously at as many stations as practicable throughout the world.*" This proposition was unanimously concurred in, and its hearty adoption by the Congress, the members of which virtually legislated for the nations they represented, at once secured the extension of the American "simultaneous" system (as inaugurated in 1870 for the United States) to the entire field of weather investigation then covered or yet to be covered by the observers of all the nations.* Soon after the adoption of this proposition at Vienna, by the courteous coöperation of scientific men and the chiefs of the meteorological weather-bureaus of the different countries, records of uniform observations, taken daily and simultaneously with the observations taken over the United States and the adjacent islands,

example of a storm central at Omaha at 8 A. M. and moving toward New York: since the difference of actual time between the two cities is nearly one and a half hour, and the storm-center might be progressing at the rate of forty-five or fifty miles an hours, the Omaha report would represent its bearings, as respects New York, from sixty to seventy miles *out of its true place?* So also all observers not on the meridian of New York would more or less mis-locate the center. Since nearly all cyclones and anti-cyclones move from east to west or from west to east, and very few in a meridional direction, the systematic misrepresentation of their relative positions in point of *longitude* works grave defects. A weather-map based on such non-simultaneous reports, instead of faithfully mirroring the sky overhanging a continent, necessarily gives it rather a *wry* face. Even at this date, we can not say that all European weather-stations take observations simultaneously. So far as they do, their present method is shaped after that introduced originally in this country by General Myer, in 1870. Professor Espy called his observations "simultaneous, or nearly simultaneous"; but evidently they were taken at the same hour of *local* time, and were, therefore, less "simultaneous" than the Smithsonian.

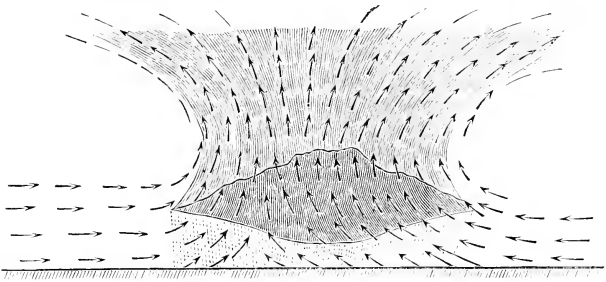
* Referring to an exchange of United States weather-reports with those of Canada, the Chief Signal-Officer, in his annual report for 1872, said: "It is to be hoped the system may be extended in the Canadas, and the coöperation be yet closer, this connection of the services becoming the first link in the grand chain of interchanged international reports destined with a higher civilization to bind together the signal-services of the world" (p. 83). The same scheme he had foreshadowed in a public document dated January 18, 1870, and also the plan of using ocean-cables for storm-warnings.

were commenced, and since then have been exchanged in semi-monthly communications. These reports, steadily increasing, now cover the combined territorial extent of Algiers, Australasia, Austria, Belgium, Central America, China, Denmark, France, Germany, Great Britain, Greece, Greenland, Iceland, India, Italy, Japan, Mexico, Morocco, the Netherlands, Norway, Portugal, Russia, Spain, Sweden, Switzerland, Tunis, Turkey, British North America, the United States, the Azores, Malta, Mauritius, the Sandwich Islands, South Africa, South America, and the West Indies, so far as they have been put under meteorological observation. On July 1, 1875, the daily issue of a printed bulletin, exhibiting these international simultaneous reports, was commenced at the Army Signal-Office in Washington, and has since been maintained. A copy of this "International Bulletin" is furnished each coöperating observer. This publication combines for the first time of which we have any record the joint labors of the nations in a research of this kind for their mutual benefit. As the network of coöperating stations already spreads over so vast a proportion of the land-surface of the globe, there is needed only the more general coöperation of the naval and merchant fleets of the world to supply ample data for a comprehensive study of the atmosphere as a unit. This need is now growingly appreciated, and nine series of marine reports, each containing the simultaneous observations of a number of sea-going vessels,* have been added to supplement the similar reports contributed by the land-observers, swelling the total observational force to 500 laborers. The harvest of physical data already garnered by this force, and daily increasing, will be invaluable for all future weather investigations. As the Committee of the Scottish Meteorological Society recently said, "This truly cosmopolitan work, which the United States are alone in a position to undertake, thanks to the liberality and enterprise of their Government, will bring before us month by month the general circulation of the earth's atmosphere, and raise if it does not satisfy many inquiries lying at the very root of meteorology, and intimately affecting those atmospheric changes which meteorologists have been recording." It will greatly enrich the meteorology of the ocean and aid navigation, by supplying data for deducing those true mean physical values which teach the mariner at sea where he may find "a fair wind and a favorable current," how he may best utilize the forces of nature and elude its terrors. It will afford material for the renovation of the climatology and sanitary meteorology of regions not now fully investigated. But, above all, it will facilitate the elucidation of the laws of storms and those associate phenomena which conspire to produce the many-colored phases of "the weather."

The cardinal object of this vast scientific enterprise, as the reader may anticipate, is the study of the atmosphere as a *unit*. The atmospheric ocean must be viewed by every thinking mind as a whole, whose

* The number of marine observers now exceeds one hundred.

complex parts act interdependently—as the various parts of a steam-engine—yet all constituting one grand mechanism. Nature's forces respect no national frontiers; and, if their mighty play is to be watched by science, its observational corps must be expanded to cover every accessible part of the globe. This will be made more apparent if we consider the intensities and movements of cyclones. The storms generated over the sea often push with resistless energy against the loftiest mountain-walls, and, surmounting their acclivities, press on as if they had felt no retardation, to sweep across an entire continent, and then, untired, to take a fresh start on a long ocean-voyage. In a rigid examination of the Signal-Service data for a period of twenty-six months, twenty-eight storm-centers, it was found by Professor Loomis, traveled eastward across the Rocky Mountains, and reached the Mississippi Valley in unimpaired vigor, having scaled that imposing barrier, 10,000 feet high, as easily as the steamship on its rapid course overrides a wave. In discussing the two cyclones which visited the Bay of Bengal in October, 1876, Mr. Elliott, Meteorological Reporter to the Government of Bengal, incidentally gives us some idea of the cyclopean forces which are developed by such storms. The average "daily evaporation," registered by the Bengal instruments, in October, is "·2 inches."* The amount of heat absorbed by the conversion of this amount of water daily over so large an area as the Bay of Bengal is enormous. "Roughly estimated," says Mr. Elliott, "it is equal to the continuous working power of 800,000 steam-engines of 1,000 horse-power." A simple calculation will show that it

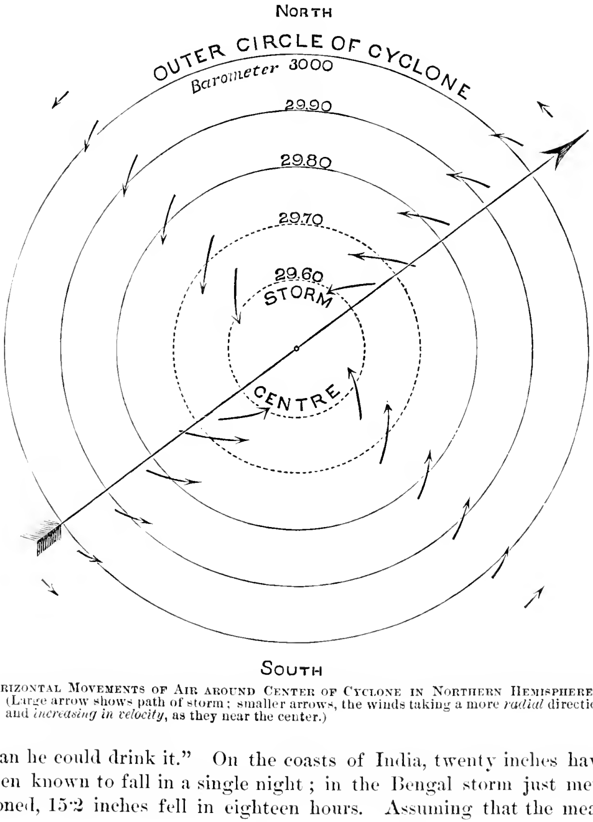


Vertical Section of the Heart of a Cyclone. (Arrows show direction of wind and the *ascending current* in storm-center; the dark-shade, nimbus, or rain-cloud.)

suffices to raise aloft over 45,000 cubic feet of water in twenty-four hours from *every square mile* of the bosom of the bay, and transport it to the clouds which overhang it. When we extend the calculation from a single square mile to the area of this whole Indian gulf, the

* "Report of the Vizagapatam and Buckergunge Cyclones of October, 1876," by J. Elliott, p. 182.

mind is lost in the effort to conceive the force which, in a day's time, can lift 50,000,000 tons! Yet, it would be easy to show that such figures, fabulous as they seem, do not adequately represent the cyclonic forces of a single storm. "The usual size of the cyclones in the Bay of Bengal," according to Piddington, "is from 300 to 350 miles; but," as he adds, "it would appear that they sometimes much exceed that extent"; and others give the average diameter as still greater than 350 miles. Now, in the passage of a cyclone over such a sheet of water, the vapor which has been slowly generated over its surface for many days is rapidly condensed and reconverted into water, and falls in the shape of torrential rains—as Dampier declared, "faster



Horizontal Movements of Air around Center of Cyclone in Northern Hemisphere.—(Large arrow shows path of storm; smaller arrows, the winds taking a more *radial* direction, and *increasing in velocity*, as they near the center.)

than he could drink it." On the coasts of India, twenty inches have been known to fall in a single night; in the Bengal storm just mentioned, 15·2 inches fell in eighteen hours. Assuming that the mean daily precipitation within the areas of storms like those just referred to is only three inches, it is evident that Mr. Elliott's calculation of the mechanical force daily exerted in the work of evaporation falls short of expressing the force exerted in the work of precipitation during a day's march of a cyclone. The latter is, however, but one of the many tremendous agencies engaged in the development of a storm of ordinary magnitude in the intratropical regions. In the extratropical and high latitudes, cyclones are much more extensive, "being seldom less than 600 miles in diameter, but oftener two or three times that amount, or even more" (Buchan); while the waves of the sea, driven by their winds, beat upon the seacoast, as Mr. Stevenson, the well-known English engineer, has estimated, with the almost incredible force of "6,000 pounds on the square foot." In the hurricane of last August, the winds on the North Carolina coast blew at the rate of from 138 to 165 miles an hour.

In citing these illustrations of the storm-phenomena which modern meteorology is charged with investigating, we have not alluded to the equally important yet far grander phenomena of "anti-cyclones," or those "atmospheric waves" of high pressure which, emanating from the higher latitudes, submerge a whole continent at once—around whose borders cyclones move as diminutive eddies playing around a rock in mid-stream. But enough has been said to show the imperative necessity for the prosecution of wide-extended or *international* research (including of course *oceanic* observations) if the laws of weather are ever to be discovered and defined. In no branch of physics is it so true, as in that of weather-lore, "a little learning is a dangerous thing." An approximation to the conception and study of the atmospheric machine as a *unit* is the *sine qua non* of all future advance in this knowledge. Phenomena such as we have just glanced at, by their immensity and by the intensity of the forces which resistlessly propel them across seas and continents, will for ever defy adequate investigation, save by an army of observers, acting simultaneously, both on the ocean and on the land, whose outposts stretch from the rising to the setting sun and from the equator to the polar circle. For, as another has so forcibly and felicitously said: "The atmosphere, unlike the ocean, is undivided and uninterrupted; and every change of state, in any part of its expanse, sends forth a pulsation of energy which is speedily felt far and wide." If the oracles of Him by whom are all things declare that he spreads "the cloud of dew in the heat of harvest," who "gathereth the winds in his fists," and once hushed the roar of the Galilean tempest, well may these wonders, ever fresh from his hand, enlist the earnest and inspiring study and observation of intelligent men everywhere. Our favored planet, not like the airless moon, is folded in the kindly bosom of an atmosphere which, while ministering nourishment to man and accommodating itself to all his movements and vicissitudes, interposes as his shield against the fiery influences of the solar system, even to arresting and consuming those countless meteoric stones, showered upon us from stellar space, before they can penetrate to the lower aërial strata. For us, at least, in respect to this sublunary scene, it is of engrossing interest, as that all-pervading organism which

> "Lives through all life, extends through all extent,
> Spreads undivided, operates unspent."

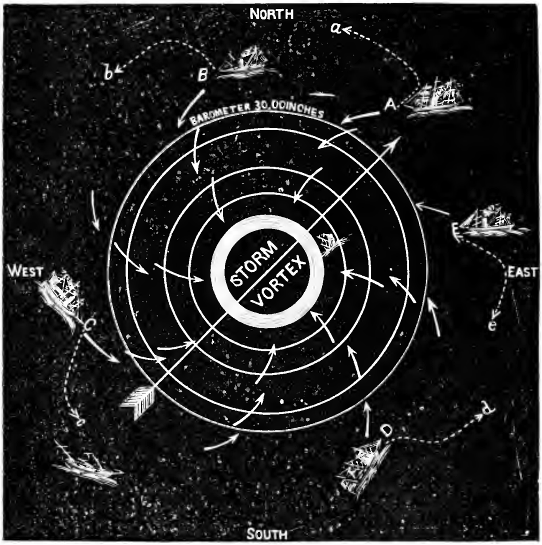
In the technical execution of this purely pioneer work, the first step was the preparation of a daily graphic and synoptic chart exhibiting all the weather observations taken simultaneously in the northern hemisphere. On the 1st of July, 1878, the Signal-Office at Washington began the regular publication of a *daily international weather-map*, charted daily and issued daily, each chart being based upon the data appearing in the "International Bulletin of Simultaneous Reports" of similar date. The daily issue of a weather-chart of this kind and scope is without a precedent in history. It illustrates the coöperation, for a single purpose, of the civilized powers of the globe north of the equator, and brings the atmospheric phenomena over the whole field of the research, and in their true relations to each other, within the easy comprehension of the student's eye. (See frontispiece.) As these charts in successive order are spread out day after day, the investigator has before him a vivid *panorama* of the physical forces in pictured action, so that he can readily trace their mutual dependence and interaction in the normal working of the ponderous, yet beautiful, atmospheric machinery.

The history of progress in the discovery of physical phenomena and their laws is intimately connected with the introduction of technical contrivances so simple that at first they attract little notice. After the invention of the mariner's compass, and the astrolabe, nothing perhaps that was done for geographical science gave it such an impulse as the chart introduced in 1556 by Gérard Mercator, by which the earth's entire surface was presented in a single picture to the geographer's eye, and by which (the degrees of latitude and longitude at all places bearing to each other the same relations they bear on the sphere itself) the navigator could readily steer his ship in straight lines. This simplest of contrivances became, in a word, an invaluable instrument of maritime exploration and discovery, the present and almost exclusive employment of which by mariners of all nations, as *the* chart for the ocean, has brought the name of Mercator down to this day in honored remembrance. Not to dwell upon the charts of Paolo Toscanelli in the fifteenth, and of Martin Behaim in the sixteenth century, so justly celebrated—the former as guiding Columbus on his great westward voyage, and the latter as blazing Magellan's perilous way toward the southern shore of South America, to circumnavigate the globe—we may well say, "Accurate maps are the basis of all inquiry conducted on scientific principles." The "International Weather-Map of Simultaneous Observations" is a generalization in itself, and offers the meteorologist every day a *bird's-eye* view of the aërial world as it actually was at that fixed moment of physical time when all the observations embodied in it were made. Nothing can be simpler or more intelligible to even unscientific eyes than a chart which, by means of suggestive symbols, displays the different elements of the weather over a hemisphere, each in its own color. Just as Mercator's projection represents the entire ocean to the mariner—as if there were no horizon or sphericity—and all objects in their true meridional bearings to each other, so the "International Weather-Chart" depicts the aërial ocean in its beautiful integrity and all its parts in their true physical relations to each other, as certified by strictly simultaneous reports. Of course, the two charts are entirely independent and different; but we refer to the invention of the old Flemish geographer merely to illustrate and enforce the immense value of every really synoptic chart as a weapon of research and as a medium of scientific discovery.

The cartographic method, by which truly synoptic views of the atmosphere are obtained, is indeed the natural accompaniment and handmaid of the method of "simultaneous weather-reports," both of which are peculiar to the national weather-service inaugurated at Washington in 1870, and, through the adoption of General Myer's proposition at Vienna, in 1873, extended to the new international weather-service. Without "simultaneous" weather observations, it is obvious, no truly "*synoptic*" weather-chart is possible; and, as has been said, the first "simultaneous" observations were those instituted by the United States in 1870. The unique and novel feature of the international weather-charts, and the feature which will most commend them to meteorologists, is that they furnish a faithful pictorial history of the atmosphere and its revolutions, enabling the inquirer to trace its currents and counter-currents, to witness the behavior of its cyclonic storms and other barometric waves as they traverse continents and deploy upon the ocean, and to form clarified conceptions of its massive yet orderly machinery. The well-known English journal of science, "Nature," "earnestly hopes that the navies and the mercantile vessels of all nations will soon join in carrying out this magnificent scheme of observations, originated by the Americans in 1873, and since then further developed and carried on by them with the highest ability and success." Its French namesake, "La Nature," said recently, when speaking of this service, "One ought not to be surprised to learn that the United States, encouraged by their first successes, are to attempt a new extension of a system of observations which has already, in so few years, produced considerable results." It would not be an easy task to predict the future results to be obtained by such a system of investigation; but we may confidently conclude that no system of weather inquiry ever before undertaken promised a richer harvest of meteorological lore than that which rigidly follows up its *simultaneous* observations and amasses its corresponding charts. Every coöperator in the work, it should be added, is encouraged and stimulated by the fact that a daily copy of both the "International Bulletin" and "Chart" is furnished by the United States, without cost, to each observer, on land or at sea, of whatever nation, who, at the request or with the sanction of the Chief Signal-Officer, coöperates in the enterprise.

We come now to the question of the practical application and utility of the data and charts published in connection with the international weather-service. And here the embarrassment arises from the multiplicity of matters, affecting almost every interest and industry of mankind, upon which this service will bear. There is not a profession, or trade, or handicraft in society which is not at every turn more or less influenced by the weather, and compelled to act upon some kind of weather-forecasts. No sooner had the Weather Bureau commenced its daily publication of "Probabilities" or "Indications," in 1870, than "whole troops of practical applications" of the data sprang into existence. It will be so with the international bulletin and charts of simultaneous meteorology.

One of the first practical applications of the simultaneous observations over the northern hemisphere will be realized in the elucidation and correction of "*the law of storms*," and of the rules for the extrication of ships from the storm-vortex. Great have been the intellect and learning employed in the settlement of this question, so important to commerce and navigation. The time-honored researches of Redfield, Reid, Espy, Piddington, Thom, and others of the past, supplemented and harmonized in a measure by those of living laborers in the storm-field, have indeed established the existence of a "law of storms" upon an unassailable foundation. But they have not defined some of its cardinal conditions. The definition of storms as "revolving gales," in which the winds blow in *concentric* circles around a calm center, has been rudely damaged by the facts every day brought to light. And the contrary theory, that the storm-winds blow in *radial* lines toward the vortex, has not fared much better. The intermediate hypothesis, that the winds blow in regular *spirals* around the center, while it apparently reconciles some of the otherwise conflicting facts, and has given a temporary quietus to the storm controversy, strictly speaking, is not less objectionable than either of the theories it affects to correct: for it apparently obliterates, or seemingly ignores, the two large and distinct classes of indisputable wind-phenomena upon which the rival deductions of Redfield and Espy were respectively based. Time has fully demonstrated the insufficiency of both the "circular" and the "centripetal" theory to account satisfactorily for all the salient and phenomenal features of a cyclone, but it has attested the immense value of them both as scientific approximations to the truth. But, it must also be said, the theory of "spiral" currents arranged symmetrically around the storm-center does not furnish a complete solution of the problems raised by a study of cyclone observations. In the domain of practical "nautical meteorology," and in its applications to the handling of ships on the outer circles of revolving gales, it is especially yet to be sifted in the light of the most exact "*simultaneous*" observations. The international weather-charts, illustrating the exacter forms of marine storms, show us that they assume very eccentric shapes (see chart, p. 305), and consequently develop variant wind systems. On the liquid expanse of the stormy North Atlantic, crowded with the steamers and sailing-ships of all nations, there exists the finest field for this investigation to be found on the globe. When these vessels become "floating observatories," rendering up accounts of their daily simultaneous weather experience, it will be comparatively an easy matter to set for ever at rest the yet disputed questions of the phenomena of cyclones, and to formulate rules for manœuvring ships so as to elude their crushing forces.



MANŒUVRING SHIPS ON THE EXTERIOR OF A CYCLONE. (The dotted lines *Aa*, *Bb*, *Cc*, *Dd*, and *Ee* show the paths of *escape* from dangerous positions; the large arrow, the storm's progressive direction; the small arrows, the cyclonic winds.)

The birth, life, and death of storms; their translations from continent to continent, with the times and directions they take in such transits; the thermometric, baric, and wind conditions around the globe at various parallels; the distribution and amount of rainfall and snowfall; the laws of our great "hot waves" and "cold waves," with many other data for settling questions of climatology, and possibly of forecasting in some degree the character of coming seasons—are some of the practical problems of every day's life which the international charts and bulletins will serve to simplify or solve. Among these, none perhaps calls for an earlier and exacter solution than the translation of cyclones from the Asiatic waters over the North Pacific Ocean to the Pacific slopes of the United States, and the kindred question of the transatlantic passage of American storms to western Europe. As we have already seen, so far as critical examination has been made of the Signal-Service weather-maps, more than one cyclone from the Pacific coast every month, on an average, overleaps the Rocky Mountains and travels eastward, reaching the Mississippi Valley and the Lakes, with its original (perhaps ocean-born) strength. The ocean is preëminently the birthplace and habitat of storms. Thence, when fully formed and densely stored with aqueous vapor—the fuel of the cyclonic engine—they assail the land-masses of the earth, and, traversing them, unless *in transitu*, they perish for want of water, and return to their native element. This is no less true of the Great Ocean that washes our Western shores, notwithstanding its name, than of the "stormy Atlantic." Uncomfortably near as the West Indian hurricanes approach our Atlantic seaboard, they affect but comparatively a small strip of the Eastern half of the United States, and often give us a wide berth. But the storms which invade our Pacific seaboard, from southern California to the mouth of the Columbia River, exert or expend their full force within the national limits, and frequently cut their broad swaths entirely across the country. The golden key, therefore, to our continental meteorology is the adequate knowledge of the barometric depressions and associate "waves of high pressure" which roll over the continent from the westward, and, in their progress, dominate the weather to the north of the thirty-fifth parallel.

Off the California coast there exists, throughout the year, a permanent area or wave of high atmospheric pressure, or a vast "anti-cyclone"—the diameter of which is something like one thousand miles. The barometer in this area reads 30·20 inches (see chart, p. 309). From its northern and western slopes, westerly and northwesterly wind-belts extend in an easterly direction across the Coast and Rocky Mountain ranges. The immense stationary anti-cyclone, from which flows off this broad belt of westerly winds, is probably due to the continental barrier arresting and accumulating the perennial equatorial current from the central zone of the Pacific Ocean; and has its counterpart in the similar area of high pressure lying in the Atlantic, off the coast of Spain and south of the Azores. The great "*highway*," therefore, along which the chief atmospheric currents move and introduce on our continent the storm-controlling and weather-producing influences, begins on the Pacific coast and traverses the country from west to east. As the Atlantic dominates the weather of Europe lying on its eastern shores, so in the Pacific Ocean is the cyclopean workshop of the atmosphere, in which are produced and whence are sent forth the meteors that perpetually travel over North America, and substantially mold its climate and weather. To cover the North Pacific, therefore, with a network of "floating observatories," contributing their "simultaneous weather-reports" to the Signal-Service Bureau, is one of the grand desiderata of American meteorology. A ship at sea is one of the best of stations for a simultaneous meteorological system. The value of its records is enhanced by the considerable change of the ship's location occurring once every hour; and the law of self-interest at least should compel every shipowner and shipmaster to enlist in a joint observational work which inures to his own safety and lends a helping hand to every meteorologist. Without the data, to be collected only by vessels sailing on the North Pacific, the prevision and prediction of storms and weather-changes that transpire in the Pacific and Western States, and are thence propagated to the East, can not be put upon a sure footing. With such marine simultaneous data, the work of weather-forecasting and storm-warning for the Pacific coast and the whole country will be greatly simplified, and the accuracy of the work much enhanced, if not assured. If the solar light of day comes first from the East, we may nevertheless predict that the flood of scientific light necessary to elucidate the still obscure phenomena of American, and especially Western meteorology, will break upon us from the Great Western Ocean. "The *improvement*" in the national tri-daily "Indications," etc., of the Signal-Service, which General Myer hopes for, as his oceanic simultaneous work "progresses," can not be doubted.

If anything more is needed to enforce this view of the immense value of North Pacific researches for the development of American weather-telegraphy, it is found in the fact that the cyclones of that ocean recurve from the Asiatic coast, and follow the warm current known as the "*Kuro Siwo*," or "*Japan Current*"—the congener of our Atlantic "Gulf Stream"—in its northeasterly extension to the northwestern coasts of the United States. This mighty "river in the sea" is a natural storm-channel. "The influence of the Kuro Siwo," says Captain Silas Bent, the original and careful investigator of its phenomena, "upon the climate of Japan and the west coast of North America is, as might be expected, as striking as that of the Gulf Stream on the coasts bordering the Atlantic." And Kerhallet, the well-known French hydrographer, tells us that it "crosses all the northern part of the Pacific Ocean, and makes itself felt on the northwest coast of America." "The track of typhoons in the China Sea," according to one of the highest nautical authorities, Labrosse, "lies between north-northwest and south-southwest, then toward the north, and afterward turns sharp around *toward the east*, in the direction of the Bashee Islands," whence in 1854 Mr. Redfield traced a number of them far away toward the American coast. These terrific rotatory gales rival, if they

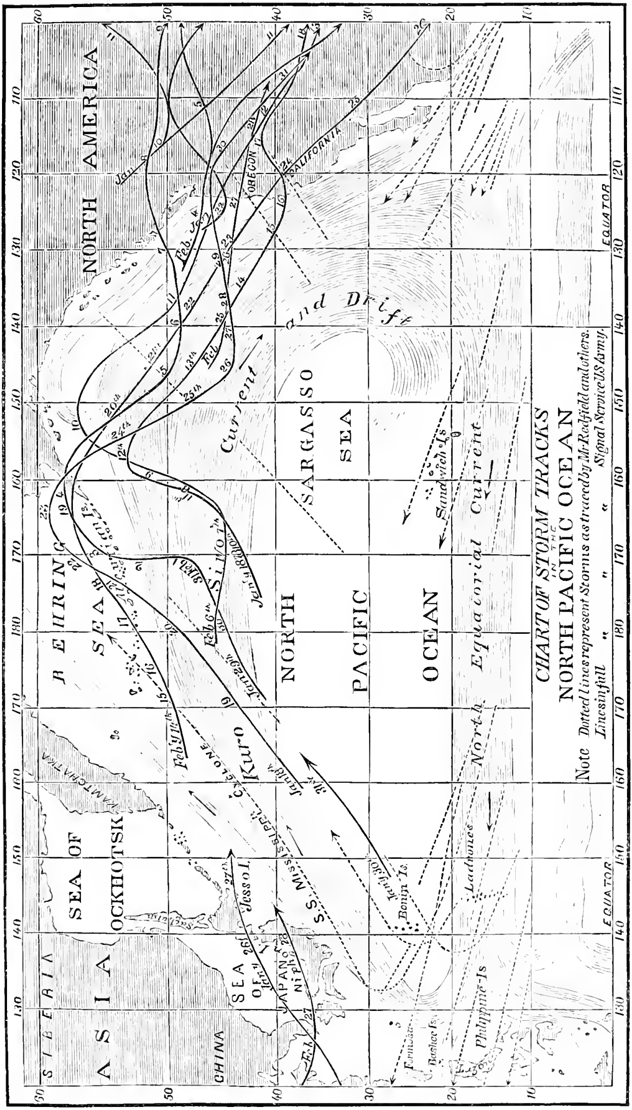
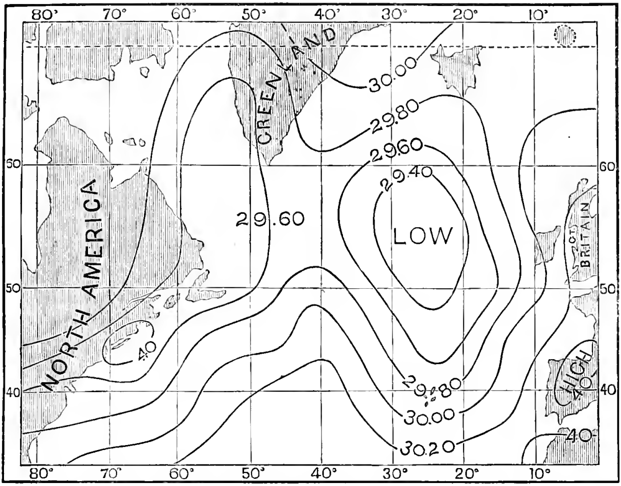


CHART OF STORM TRACKS
IN THE
NORTH PACIFIC OCEAN
Note Dotted lines represent Storms as traced by Mr Redfield and others.
Lines in full " " " Signal Service U.S. Army.
NORTH AMERICA
ASIA
SIBERIA
CHINA
KAMTCHATKA
SEA OF OCKHOTSK
BEHRING SEA
SEA OF JAPAN
NORTH PACIFIC OCEAN
SARGASSO SEA
Kuro Siwo Current and Drift
North Equatorial Current
OREGON
CALIFORNIA
Aleutian Is.
Sandwich Is.
Bonin Is.
Ladrones
Philippine Is.
Bashee Is.
Formosa
Jesso I.
Niphon
S.S. Mississippi
CYCLONE
EQUATOR

do not exceed, in intensity, the fiercest Atlantic hurricanes. The cyclone or typhoon of the U. S. steamship Mississippi, October 6, 1854, with that of the U. S. storeship Caprice, and the steamship Susquehanna, July 17 and 19, 1853, in Commodore Perry's Japan Expedition, are among the most memorable storms of history on any sea, and illustrate the magnitude and might of those atmospheric forces so characteristic of the Great Ocean, whose meteorology is now to be brought under strictly simultaneous surveillance and studied in its close causal connections with that of our own country.

As the investigation of the Pacific's meteorology is so important to America, the same system of observations applied to the Atlantic reaches to the roots of European meteorology. It is well known that the atmospheric conditions which shape European weather and climate are propagated over the French and British coasts from the Atlantic, so that every intelligent storm-warner and weather-forecaster in Europe casts a wistful eye to the western waters to catch some premonition of what is to befall his coasts. Propositions to buoy in the mid-Atlantic ships, equipped with self-registering barometers and weather-indicators and connected by telegraphic cables with the shore, which would flash reports of precursory changes to the central Signal-Office, were suggested by General Myer to meet a deeply-felt need. It has also been very seriously proposed to dispatch carrier-pigeons by the westward-bound English steamships, to bear back weather-reports from points two hundred or more miles at sea, in the hope that the London office might have data for more timely weather-warnings. "It is possible," says the Russian meteorologist Wœikof, "that in October *Atlantic storms may reach as far as Yakutsk*" (in northeastern Siberia) which is farther from the Atlantic than England is from the Pacific Ocean. "In Europe," Mr. Buchan tells us, "stormy weather is accompanied by a diminution in the atmospheric pressure, the center of which, after traversing more or less of the Atlantic, arrives on the coast of Europe." *One* weather-report from the Atlantic, if only made a few hundred miles from the British coast, would be worth, for all practical purposes of storm-prediction, more than dozens of continental reports. If, indeed, the international system does not supply the needed ocean-reports in time for the European work of daily storm-warning, its daily charts show *the conditions which usher in the various weather-changes* upon the European coasts. They show, moreover, the *tracks* which, at each season, Atlantic cyclones are wont to select and pursue as they approach Europe, and the *rates* at which they traverse these tracks. Given these mean data, deducible from the international weather-charts, and the chief elements are had for deciding any special question of weather that arises in the daily work of forecasting. As a late writer says: "The most abstruse discussion of meteorological data have hardly another object than the determination of the average conditions of the climate of each place, and of the amount of variability which may be anticipated in the march of each element. What is this but forecasting?" Every increase of simultaneous reports is, therefore, another approximation to that knowledge which would, if sufficiently full, enable the European meteorologist to foresee



A "Low Barometer," or Cyclone, crossing the Atlantic from America to Europe.
(From "International Weather-Map," February 9, 1878.)

and to give every day more timely forewarning of impending variations in the weather and "the march of each element." But this is the grand end which all such international research contemplates. "From the use of synchronous weather-maps," another prominent English meteorologist tells us, "there has sprung up in recent years a new science of the winds. With the principles of this science all the more reliable rules of weather-forecasting are most intimately connected. We no longer think of judging of coming weather merely by the aspect of the sky and an examination of an individual barometer. We invariably refer—I do not say to the weather-reports of a few hours previous, for we often have neither these nor any weather-reports at all at hand—but *we invariably refer to rules already deduced from the long study of weather-maps.* The man who ignores these rules had better, in my opinion, leave all attempts at weather-forecasting alone. At best his weather-lore will not rise much above that of the bees, which fly to the hive, often to their own detriment, whenever a dark cloud covers the sun." We cite these words as expressive of the wise dependence which the most skillful European meteorologists put upon the weather-charts of the past. How much more light will they derive from the new international "*simultaneous*" weather-maps! While the scientific world is despairing of finding adequate mechanical means of mooring a floating weather-station in mid-Atlantic to cable its reports to land, the necessity for such a station is being gradually superseded by the development of researches which if studied will supply adequate rules for weather-forecasting without mid-Atlantic reports. The immediate value of every means which offers any approximation to correct storm-warnings for the British and French coasts—frequented by the navies and merchant marines of every flag—is beyond calculation in dollars and cents.

The ultimate value of the temperature and rainfall statistics obtained by this research, especially in their application to agriculture, can not be questioned. Even if such data were of no avail for the general work of weather-forecasting, they reach into the sphere of all farming operations, and are utilized by all classes. One of the most striking exemplifications of this fact has been furnished by Governor Rawson, of the island of Barbadoes, who, in an official paper, has used the rainfall reports "in calculating the probability, or expectation, of coming seasons as respects the yield of the sugar-plantations."

The long-protracted and often torrential precipitation that drenched the British Islands and large portions of western Europe last summer (1879), had been preceded by long-protracted and abnormal chilling of those countries, whose crops were blighted or dwarfed for want of sunshine and ruined by too frequent down-pours. Now, it is a fact worthy of deep reflection that on June 12th, before this dreary and desolating summer had set in, the English journal of science, "Nature," published a summary of thermometric data from ninety-two stations, which demonstrated that "the cold weather, for the six months ending May 1, 1879, exceeded in intensity" (that of) "any other past period of cold weather in these islands of like duration, of which we have an exact and authentic record." Great Britain on the 1st of May was then abnormally refrigerated; these islands, and we may add the adjacent continent, were ready to act as powerful *condensers* of the tropical and North Atlantic vapor wafted over them in enormous volumes by the southwest or "anti-trade" winds, which especially prevailed in summer. But more significant still were the barometric conditions prevailing over Iceland, which so greatly affected the weather of the British Isles. The spring of 1879 was unusually *cold*, and the international weather-charts, prepared by our Signal-Service, show unusually *high* pressures throughout April, 1879, over Iceland, just as occurred in July, 1867, when there was a memorably cold spell in Great Britain—owing to the fact, as Mr. Buchan explains it, that "the pressure being low in Norway and countries surrounding the Baltic, and *high in Iceland*, Scotland was thus placed in the *cold Arctic current* which set in from Iceland toward the Baltic."

Now, with such clear barometric and thermometric conditions in and around Great Britain, a "cold, wet summer" in 1879 was almost inevitable, and a prediction to that effect, based on the simultaneous international data, would have been justifiable. Of course, new conditions might arise late in June, but the conditions prevalent, according to all physical probability, authorized such a forecast at the commencement of the summer, and would have been of incalculable value. Ask the British farmer what he would have freely paid in June to have gained some idea of the July weather! Or ask the English merchant what he would have freely given in June for a tolerably correct crop-forecast for the summer of 1879! Yet this is no hypothetical case, but one familiar to all, involving a whole nation in agricultural and financial distress, against which, with international reports from the Faroe Islands and Iceland, it could have been forewarned.

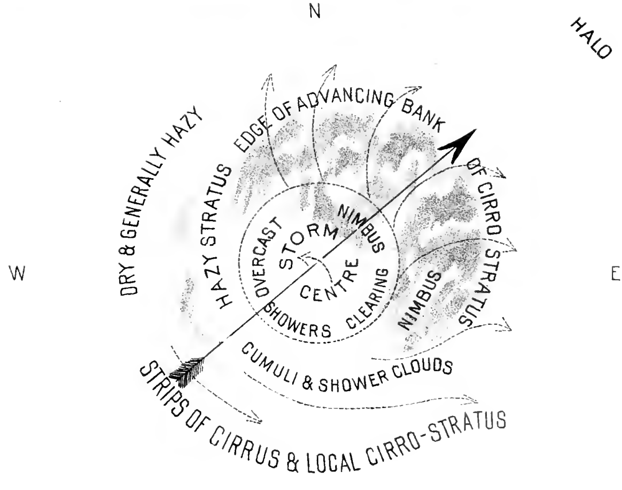
The collection of the "international" cloud-observations—especially those taken at sea—opens one of the most fertile and fascinating fields, not only for the elucidation of the profoundest atmospheric problems by the theoretical scientist, but for the *popularization* of meteoric knowledge. The clouds are *Nature's weather-guides*, at all times serving to preannounce the approach of storms, or the return of clear weather. Until the middle of the seventeenth century (when Torricelli's experiments led to the invention of the barometer), and long after, the clouds furnished the only weather-indications which the world had. And, the more modern meteorology is developed, the more do the ablest of its leaders seek to understand these unerring monitors of every weather-change. Varied as they are, their forms may be reduced to two or three types, so defined and imposing that the most unscientific can learn to recognize them and construe their meaning. The international observers enter on their blanks the amount and direction of clouds. "The most valuable of weather-signs," says Mr. Ley, "are obtained not so much from the shape of the clouds as from the *directions* from which clouds of different levels are observed to travel, and it is these weather-signs which, in the present state of our knowledge, can be most readily reduced to definite rules."

Take a single illustration of the utility which such rules would have for the farmer, the sailor, or any close observer of the sky. Our storm-centers are generally preceded by a great bank of those clouds to which the name cirro-stratus is given. They are composed largely of freezing or frozen vapor, floating at great elevations, and often very far in front of the depression and over the belt of country which is to receive its rainfall. They move in parallel lines, and are distinguished by their thread-like and attenuated delicacy, as well as by their altitude—from 20,000 to 40,000 feet—from all local clouds. Outlying streaks of the cirro-stratus, frequently visible from twenty to one hundred miles in advance of the main pack, "like pioneers of the coming army," can easily be detected. But the main body, since it forms the familiar *halo*, can not be overlooked. It is the timely omen of impending disturbance, delivering its faithful warning long before the barometer begins to fall and tell its confirmatory tale. The accompanying cloud-illustrations, constructed, with some variations, after Mr. Ley's designs, will illustrate the chief weather-changes. Fig. 1 represents cirrus and cirro-stratus forming far in front of a cyclone, while yet the barometer has not begun to fall decidedly. Fig. 2 shows the cloud-system attending one of our storm-centers, as viewed from a point say 25,000 feet high (above the disturbance), the whole system borne along in the broad, horizontal "antitrade-wind" belt, from southwest to northeast, the scale of miles 200 to the inch, and the rate of progress fifteen miles an hour.

Could the rural populations and those whose occupation calls them much out of doors be assisted in interpreting these and similar phenomena, however untutored they might be in meteorologic terms and theories, they would soon learn to forecast many of the great weather-changes for themselves. But as the storm-signaling clouds, conspicuous to all, fly aloft in those mighty "upper currents" which, observation shows, attain not uncommonly velocities of one hundred and twenty and sometimes even one hundred and fifty miles an hour, none but *strictly "simultaneous"* weather-reports can adequately or truthfully reflect their actual, ever-flitting movements as related to storm-vortices and other atmospheric phenomena, whose approach and force they foretoken.

Once more. The most popular and profitable use to which meteorologic observations can possibly be put would be, if it is practicable, to *forecasting in part the character of coming seasons*—whether the next winter will be mild or severe, or the approaching summer wet or dry. It is certain that such forecasts will not be made until the network of observing stations is so enlarged as to record the temperature and other conditions over extensive portions of the oceanic, as well as the solid face of the globe. The northern hemisphere at least must be belted with stations returning simultaneous reports before *season-predictions* can be successfully attempted. But, with a broad girdle of observations around the middle latitudes, would it even then be possible to foreshadow the abnormal or extreme heat or cold of a coming summer or winter? It may seem premature to offer any reply to such an interrogatory; and yet it may not be as unanswerable as it seems. It is now pretty clearly ascertained that the earth in its orbital revolution is subjected to very decided periodic planetary influences, which sometimes destroy the balance of the seasons. The researches of Mr. Meldrum and others appear to corroborate the long-suspected physical connection between terrestrial cyclones and those grand solar atmospheric storms which produce or constitute sun-spots. A recent writer, summing up the latest results obtained from these and many like investigations, concludes that "the solar spots and temperatures

Fig. 1.



N
HALO
W
E
S
DRY & GENERALLY HAZY
HAZY STRATUS
EDGE OF ADVANCING BANK OF CIRRO STRATUS
NIMBUS
STORM CENTRE
OVERCAST
SHOWERS
CLEARING
NIMBUS
CUMULI & SHOWER CLOUDS
STRIPS OF CIRRUS & LOCAL CIRRO-STRATUS

Fig. 2.

change in parallel cycles, and affect every feature in terrestrial meteorology."

But, apart from every aid furnished by cosmic meteorology to that of our individual planet, the extension of the international simultaneous weather-reports will, we believe, ultimately afford the data requisite for approximately forecasting some main features of the seasons. A single example (the great heat of last October on the eastern side of the United States) will illustrate the possibility of attaining in some degree this long-desired object, which, like an *ignis fatuus*, has eluded the pursuit of men for so many ages. The summer of 1879 presented in North America no strongly marked high pressure; but after the 24th of July the barometric conditions were generally "low," and in the "Monthly Weather Review" for August, the Signal-Service stated: "The barometric pressure, as compared with the means of the

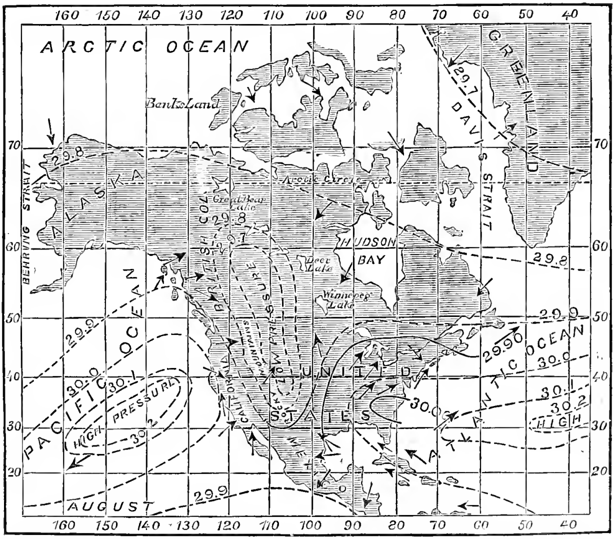


CHART OF EQUAL BAROMETRIC PRESSURES DURING AUGUST, IN AND AROUND NORTH AMERICA. (Arrows show *prevailing winds* for August.)

seven preceding years, shows that *the mean of the entire country has been abnormally low.*" We may compare the atmosphere then resting upon the interior to a vast and fixed *dry cyclone*, the elongated central area of which covered the Upper Lake region, and the country stretching northward, probably to the sixtieth parallel of latitude—the whole extent of the depression not less than 1,500,000 square miles, and the pressure ranging from 29·90 to 29·70 inches. It has long been known that such a "barometric trough," or stationary depression, forms over the northwestern portion of this continent every summer, when the soil is highly heated by the sun, and the air-strata above it become highly rarefied by terrestrial radiation ; Mr. Buchan, on his isobaric charts, assigns to it in July a mean pressure of 29·80 to 29·70 inches. Now, by "the law of the winds," the effect of this barometric depression would be to set up an indraught, somewhat resembling that caused by an ordinary cyclone, around whose center, in our hemisphere, the air draws from right to left, and moves on all sides toward the vacuum. Necessarily, therefore, toward the central belt of this vast continental depression (which during last August covered the interior of our continent up to the Arctic Circle), as into an aërial hollow, the air would flow from the surrounding regions of high pressure, which in that month always lie to the southward in the Gulf of Mexico, and in the extratropical parts of the Pacific. Could the Signal-Service barometric observations have been supplemented in August by like simultaneous observations taken in central British America, so as to determine the extent and intensity of the low pressure there, the anomalous autumn of 1879 could have been in no small measure foreseen and foreannounced. A "warm wave" was then rolling northward and likely to continue. Could the international system of reports have been extended to the upper valley of the Saskatchewan before this enormous barometric anomaly developed, the prevailing weather of last September and October could have been then measurably foreshadowed, with almost as much certainty as, when a "cold wave" from the north is moving over the Lakes any day in January, the Signal-Office indicates "cold weather" for the interior of the country.

But enough has been said on this part of our subject. The necessity of studying the atmosphere as a *unit* need not be further pressed ; for, as Dove forcibly said, "it is, as its name shows, a great steam-apparatus, whose reservoir is the ocean, its furnace the sun, and whose condensing vessels are the higher geographical latitudes," so that only when viewed as a whole can its operations be clearly understood. The *simultaneousness* of the present international system insures the accuracy of the results that may be deduced. And the *international chart* acts as a sort of lens by means of which the scattered rays of meteorological light are concentrated in a focus upon the dark points of the science. It is but just to add that the credit of originating, organizing, and elaborating this simultaneous system, both of the ocean meteorology and that of the land, belongs to General Myer, who, in the execution of his plans, has been seconded by the indefatigable labors of his assistants in the Washington Weather Bureau, and sustained by the energetic coöperation of all foreign weather-services.

The extension of this research can not fail to afford the diligent investigator a magnificent view of the complicate and exquisite adaptations of the atmospheric forces. Humboldt records the circumstance that, when, like Balboa on the summit of the Sierra de Quarequa in Darien, he and his companions from the top of the Andes caught their first view of the Pacific Ocean, so great was their joy, they forgot to open their instruments, and every thought was hushed that they might drink in the scene expanding before them. How much more will the meteorologist of the near future, whose mental eye catches a clear glimpse of the Aërial Ocean, mirrored in the modern chart, be lost in admiration, yet constrained to admit with the ancient seer, "Lo! these are but parts of His ways; how little a portion is heard of Him, but the thunder of His power who can understand?"

JOHN STUART MILL.

By ALEXANDER BAIN, LL. D.,

PROFESSOR OF LOGIC IN THE UNIVERSITY OF ABERDEEN.

V.

WHAT I have to say on the ten years from 1848 to 1858 may be conveniently introduced by a reference to the "Autobiography," p. 237. Mill states that, for a considerable time after the publication of the "Political Economy," he published no work of magnitude. He still occasionally wrote in periodicals, and his correspondence with unknown persons on questions of public interest swelled to a considerable amount. He wrote, or commenced, various essays on human and social subjects, and kept a watch on the progress of public events.

The year 1850 was chiefly noted for the first important revision of the "Logic," namely, for the third edition. He had to answer many attacks upon it, including a pamphlet by Whewell. As I was absent from London while this was going on, I had a good many letters from him, chiefly on Whewell's criticism, of the weakness of which he had a very decided opinion. I suggested some alterations and additional examples, but I scarcely remember what they were. The edition was printed in November; and no revision of anything like the same extent was undertaken till the eighth edition came out in 1872.

The "Political Economy" was subject to more frequent revisions, and occupied a good deal of his attention at one time or other, but I did not keep pace with him on that subject.

In the spring of 1851 took place his marriage to Mrs. Taylor. In the autumn of that year I took up my abode in London again, and remained there or in the neighborhood till 1860. I continued to see him at intervals in the India House, but he had changed his residence, and was not available for four-o'clock walks. He could almost always allow a visitor fifteen or twenty minutes in the course of his official day, and this was the only way he could be seen. He never went into any society except the monthly meetings of the Political Economy Club. On some few occasions a little while after his marriage, Grote and he and I walked together between the India House and his railway-station.

Only three of his reprinted articles belong to the period I am now referring to; but he must have written for the "Westminster Review" at least one or two that were not reprinted. I can not help thinking that the failure of his energy was one chief cause of his comparative inaction. As an instance, I remember, when he first read Ferrier's "Institutes," he said he felt that he could have dashed off an article upon it in the way he did with Bailey's book on "Vision"; and I can not give any reason why he did not.

He wrote for the "Westminster," in 1849, a vindication of the French Revolution of February, 1848, in reply to Lord Brougham and others. In French politics he was thoroughly at home, and up to the fatality of December, 1851, he had a sanguine belief in the political future of France. This article, like his "Armand Carrel," is a piece of French political history, and the replies to Brougham are scathing. I remember well, in his excitement at the Revolution, his saying that the one thought that haunted him was—"Oh, that Carrel were still alive!"

It was for the "Westminster" of October, 1852, that he wrote the article on Whewell's "Moral Philosophy." What effect it had upon Whewell himself I can not say; he took notice of it blandly in a subsequent edition of his "Elements of Morality," in reviewing objectors generally, omitting names. John Grote thought that, in this and in the "Sedgwick" article, Mill indulged in a severity that was unusual in his treatment of opponents. I could not, for my own part, discover the difference. Yet it is no wonder, as he told me once, that he avoided meeting Whewell in person, although he had had opportunities of being introduced to him (I suppose through his old friend Mr. Marshall, of Leeds, whose sister Whewell married).

In 1853 he wrote his final article on Grote's "Greece," in which he enters with enthusiasm into Grote's vindication of the Athenians and their democratic constitution. He was, quite as much as Grote, a Greece-intoxicated man. Twice in his life he traversed the country from end to end. I remember, when I met him at the India House after his first tour, he challenged me to name any historical locality that he had not explored.

In 1854 he had an illness so serious that he mentions it in the "Autobiography." It was an attack in the chest, ending in the partial destruction of one lung. He took the usual remedy of a long tour, being absent about eight months, in Italy, Sicily, and Greece. I remember Sir James Clark giving a very desponding view of his state; the local disease, however, he said, was not so serious as the general debility, and, in all likelihood, he never would be fit for any other considerable work. According to a remark made to Grote by Peacock, the head of his office, his absence was severely felt at the India House. He rallied, nevertheless, and resumed his usual routine.

In the year following his recovery, 1856, his two seniors in the Examiner's office retired together, and he became head of the office. This made an entire change in his work: instead of preparing dispatches in one department, he had to superintend all the departments. The engrossment of his official time was consequently much greater; and he had often to cut short the visits of friends. In little more than a year after his promotion, in the end of 1857, the extinction of the Company was resolved upon by the Government, and he had to aid the Court of Directors in their unavailing resistance to their doom. For this purpose, he drafted the "Petition to Parliament" in behalf of the Company, in which he brought to bear all his resources in the theory and practice of politics. The petition, as ultimately submitted, after some slight amendments by the Court of Directors, was pronounced by Earl Grey the ablest state-paper he had ever read. I do not mean to advert to its contents, further than to quote the two introductory sentences, the point and pungency of which the greatest orator might be proud of:

"That your petitioners, at their own expense, and by the agency of their own civil and military servants, originally acquired for this country its magnificent empire in the East.

"That the foundations of this empire were laid by your petitioners, at that time neither aided nor controlled by Parliament, at the same period at which a succession of administrations under the control of Parliament were losing to the Crown of Great Britain another great empire on the opposite side of the Atlantic."

Several other documents were prepared by Mill for the Court of Directors, while the abolition of the Company was under discussion in Parliament. It so happened that the Liberal Government, which first resolved on the measure, retired from office before it was carried, and the Government of Lord Derby had to finish it. Under the management of Lord Stanley, as President of the Board of Control, the new India Council was much more assimilated to the constitution of the old Court of Directors; and I am inclined to believe that the modification was in great measure owing to the force of Mill's reasonings.

The passing of the bill led to his retirement from the India House. He told Grote that, but for the dissolution of the Company, he would have continued in the service till he was sixty. An attempt was made to secure him for the new Council. After the chairman, he was the first applied to by Lord Stanley to take office as a Crown nominee. In declining, he gave, as his reason, failing health; but, had he been stronger, he would have still preferred retirement to working under the new constitution.

His deliverance from official work in 1858 was followed by the crushing calamity of his wife's death. He was then on his way to spend the winter in Italy, but immediately after the event he returned to his home at Blackheath. For some months he saw nobody, but still corresponded actively on matters that interested him. His despondency was frightful. In reply to my condolence, he said: "I have recovered the shock as much as I ever shall. Henceforth, I shall be only a conduit for ideas." Writing to Grote, he descanted passionately on his wife's virtues: "If you had only known all that she was!"

In the beginning of 1859 I was preparing for publication my volume on "The Emotions and the Will." I showed the manuscript to Mill, and he revised it minutely, and jotted a great many suggestions. In two or three instances his remarks bore the impress of his lacerated feelings.

He soon recommenced an active career of publication. The "Liberty" was already written, and, as he tells us, was never to be retouched. His pamphlet on "Parliamentary Reform," written some years previously, was revised and sent to press. On this he remarked in a letter: "Grote, I am afraid, will not like it, on account of the ballot, if not other points. But I attach importance to it, as a sort of revision of the theory of representative government." A few days later he wrote, "Grote knows that I now differ with him on the ballot, and we have discussed it together, with no effect on either."

Of course the pamphlet was well reasoned, but the case against the ballot had not the strength that I should have expected. The main considerations put forward are these two: First, that the electoral vote is a trust, and therefore to be openly exercised; second, that, as a matter of fact, the coercion of the voter by bribery and intimidation has diminished and is diminishing. The argument from "a trust" was not new; it had been repeatedly answered by Grote and by others. The real point at issue was, whether the withdrawing the elector from the legitimate control of public opinion be not a less evil than exposing him to illegitimate influence; and this depends on the state of the facts as to the diminution of such influence. Experience seems to be against Mill on this head; and it is unfortunate for his political sagacity and prescience that the Legislature was converted to the ballot after he had abandoned it.

The "Liberty" appeared about the same time. The work was conceived and planned in 1854. While thinking of it, he told Grote that he was cogitating an essay to point out what things society forbade that it ought not, and what things it left alone that it ought to control. Grote repeated this to me, remarking, "It is all very well for John Mill to stand up for the removal of social restraints, but as to imposing new ones I feel the greatest apprehensions." I instantly divined what the new restraints would be. The volume must have been the chief occupation of his spare time during the last two years of his official life. It is known that he set great store by the work, and thought it would probably last longer than any of his writings, except perhaps the "Logic."

The old standing question of freedom of thought had been worked up, in a series of striking expositions, by his father, in conjunction with Bentham and the circle of the "Westminster Review"; he himself, from his earliest youth, was embarked in the same cause, and his essays were inferior to none in the power and freshness of the handling. The first part of the "Liberty" is the condensation of all that had been previously done; and, for the present, stands as the chief text-book of freedom of discussion. It works round a central thought, which has had a growing prominence in later years, the necessity of taking account of the *negative* to every positive affirmation; of laying down, side by side with every proposition, the *counter-proposition.* Following this cue, Mill's first assumption is, that an opinion authoritatively suppressed may possibly be true; and the thirty pages devoted to this position show a combination of reasoning and eloquence that has never been surpassed, if equaled, in the cause of intellectual freedom. The second assumption is that an opinion is false. Here his argument takes the more exclusive form of showing the necessity of keeping in the view the opposite of every opinion, in order to maintain the living force of the opinion itself. While there is much that is effective here also, I think that he puts too great stress upon the operation of negative criticism in keeping alive the understanding of a doctrine. It is perfectly true that, when an opinion is actively opposed, its defenders are put on the *qui vive* in its defense, and have, in consequence, a far more lively sense of its truth, as well as a juster view of its meaning and import; but the necessity of keeping up imaginary opponents to every truth in science may easily be exaggerated. We need not conjure up opponents to gravitation so long as a hundred observations and a hundred thousand ships are constantly at work testing its consequences. This is the substitute that Mill desiderates (page 80) for the disadvantage of the cessation of controversy in truths of great magnitude.

When he proceeds to illustrate the enlivening influence of negation by the case of ethical and religious doctrines, I think he fails to make out his case. It may be true enough that, when a creed is first fighting for reception, it is at the height of its fervor, but the loss of power at a later stage is due to other causes than the absence of opponents. Mill's illustration from Christianity is hardly in point. Never since the suppression of pagan philosophy was Christianity more attacked than now; but we can not say that the attacks have led, or are likely to lead, to a resuscitation of its spirit in the minds of Christians: the opposite would be nearer the truth.

The last branch of the argument for free thought is constituted by Mill's favorite doctrine that conflicting doctrines usually share the truth between them. This view is, I think, both precarious in itself, and of very doubtful relevance to the author's main thesis. The example from the two state parties—the party of order and the party of progress—will not stand a severe scrutiny. Not to mention, what he admits, that there is perfect freedom of discussion on the matter, the war of parties is, in point of fact, scarcely conducted according to his ideal. More to the point is the well-known passage on Christian morality, which he regards as a series of half-truths, needing to be made up by truths derived from other sources. As far as his main purpose is concerned, I think all this belongs to the first branch of the argument, and might have been included there: that first branch containing, to my mind, the real strength of the contention for freedom of thought.

The second half of the book is on liberty of conduct, as against the restraints of our social customs. This is introduced by a chapter on individuality, considered as one of the elements of well-being. Excellent as are many of the author's remarks, there are various openings for criticism. The chief thing that strikes me is the want of a steady view of the essentials of human happiness. I shall have to notice again the defects of Mill's Hedonic philosophy. I think that he greatly exaggerates the differences between human beings as regards the conditions of happiness. The community of structure in our corporeal and mental framework far exceeds the disparities: there are certain easily stated requisites, in the possession of which no one could be very unhappy; while the specialties needed to impart to a given individual the highest degree of felicity are seldomer withheld by the tyranny of custom than by causes that society can not control. Mill pleads strongly for the energetic natures, for the exuberance of spontaneity and strong impulses. But energy as such is not thwarted; and the difficulty will always remain, that superabundant energy is exceedingly apt to trench upon other people's rights. Mill too closely identifies energy with originality or genius, and genius with eccentricity. In regard to all these characteristics, many fine distinctions need to be drawn, over and above what Mill gives us. When he talks of the present state of Englishmen as a state of collective greatness and diminishing individuality, it takes a little reflection to see what he is driving at. Nor is his reference of the unprogressiveness of the East to the despotism of custom a wholly satisfactory explanation; the problem of stationary societies is still undecided.

The chapter following, entitled "The Limits to the Authority of Society over the Individual," helps us better to his real meaning. He lays it down as an axiom that society should interfere only in what concerns itself. One might suppose that this would have passed as an axiom, instead of being caviled at on all hands. Why should society, more than any other entity, interfere with what does not concern it? Even accepting the axiom, we may yet work it in society's favor by those numerous pretexts whereby individual action is alleged to have social bearings; but to refuse the axiom itself argues some defect of intelligent comprehension.

As a piece of vigorous composition, this chapter is not inferior to any in the book; it is admirable as an exposition in practical ethics, and might be enshrined as a standing homily in the moral instruction of mankind. It does what homilies rarely do, namely, endeavor to draw precise lines between social duty and individual liberty; and reviews the more notable instances where society still tyrannizes over minorities. Still, the instances adduced seem scarcely to justify the denunciations of the author; they are the remains of past ages of intolerance, and are gradually losing their hold.

It is in his subsequent chapter of "Applications" that we seem to approach his strongest case—but it is little more than hinted at—I mean the relationship of the sexes. It hardly admits of question that any great augmentation of human happiness that may be achieved in the future must proceed first upon a better standard of worldly circumstances, and next upon the harmonizing and adjusting of the social relations. After people are fed, clothed, and housed, at a reasonable expenditure of labor, their next thing is to seek scope for their affections; it is at this point that there occur the greatest successes and the greatest failures in happy living. The marriage relation is the most critical of any; and we have now a class of thinkers that maintain that this is enforced with too great stringency and monotony. To attain some additional latitude in this respect is an object that Mill, in common with his father, considered very desirable. Both were strongly averse to encouraging mere sensuality; they were not prepared with any definite scheme of sexual reform; they merely urged that personal freedom should be extended in this respect, with a view to such social experiments as might lead to the better fulfillment of the great ideal that the sexual relation has in view.

The "Liberty" was exposed to a good deal of carping in consequence of Mill's admitting unequivocally that a certain amount of disapproval was proper and inevitable toward persons that behaved badly to themselves. It was said, What is this, after all, but a milder form of punishing them for what does not concern either us or society at large? He fully anticipated such a remark, and I think amply disposed of it, by drawing the very wide distinction between mere lowered estimation and the treatment proper to offenders against society. He might have gone further, and drawn up a sliding scale or graduated table of modes of behavior, from the most intense individual preference at the one end to the severest reprobation at the other. At least fifteen or twenty perceptible distinctions could be made, and a place found for every degree of merit and demerit. Because a person does not stand high in our esteem, it does not follow that we are punishing or persecuting him; the point when punishment in any proper sense could be said to begin would be about the middle of the scale. Mill remarks justly: "If any one displeases us, we may express our distaste and stand aloof from such an one; but we shall not therefore feel called on to make his life uncomfortable," still less to send him to prison or to the stake.

A ROGUISH HOUSEHOLD PET.

By FRANK BUCKLAND.

AS company for the monkeys and myself, for many years past, I have had a "Jemmy." All my Suricates I call "Jemmys." The Latin name is *Suricata Zenick*. Jemmy is a very pretty little beast, somewhat like a small mongoose or very large rat. His head is as like the head of a hedgehog as can be imagined. His color is light brown, with darker stripe down the sides. He is an African animal, and lives in burrows on the plains, whence he is sometimes called the African prairie-dog, or the *meercatze*. Captain Adams tells me that, when in South Africa, he has frequently come across a camp of Jemmys. The plain will appear covered with them, sitting up motionless like so many ninepins; at the least notice, they simultaneously and in an instant disappear down their holes.

SURICATE (*Suricata Zenick*).

I would like now to say something of the habits of this pretty little fellow, which was kindly given to me by Mr. Forbes Nixon. Jemmy the Third (for I have previously had two Jemmys) was allowed the free range of the whole house. He was full of curiosity and restless-ness, running continually from one room to another. He very seldom walked; his pace, on the contrary, was a short gallop, or rather canter. When on the move he always gave tongue, like a hound on a scent. It is impossible to describe his melodious cry in words. When handled and petted he would utter a sharp bark, not unlike that of a dog; and, if in a very good humor, I could, by imitating him, make him bark alternately with myself. His great peculiarity was his wonderfully intelligent and observing look. He had the peculiarity also of sitting up on his tail, like a kangaroo; his fore-paws on this occasion were like a dog's when begging. He was very fond of warmth, and would sit up inside the fender and warm himself, occasionally leaning back against the fender and looking round with the satisfied air of an old gentleman reposing after dinner. When the morning sun came into the room, Jemmy would go and sit in the sunbeams and look out of the window at the passing cabs and omnibuses. When doing this he had a way of turning round very sharply, and looking with his little pig's eyes at me and back, as much as to say, "What do you think of that?" When breakfast came up he would dance round me on his hind-legs, watching for something. I often put him on the breakfast-table; if I did not put him up he would climb up uninvited. It was very amusing to see him go and smell the egg, and, in his own language, swear at it for being hot. He could not understand its being hot enough to burn his nose; raw eggs were his special favorites. His great delight was to be allowed to upset the sugar-basin, and then scratch about among the lumps of sugar. He was also very fond of cream, and it was most amusing to see him try to get the little drops of cream I had left for him out of the cream-can, as left by the milk-woman. I am obliged to have my cream in this little can, as the cats, marmoset, or something else would be sure to have it before I came down. I placed the cream-can on the floor, and it was fun to see Jemmy try to force it open with his teeth, to get the cream out; he used quite to lose his patience with this metal cream-can.

After breakfast, Jemmy generally had a stand-up fight with the monkeys. He would inspect (from the outside) the bottom of the monkey-cage. If he discovered any portion of the monkeys' breakfast which he thought might suit him, he would immediately try to steal it by thrusting his arms through the bar. The monkeys invariably resented this indignity. The carroty, old, crippled monkey, Jane, could only make eyes and faces at him. The wicked, impudent "Little Jack" would jump up and down like an India-rubber ball, all the time well inside the cage, where Jemmy could not get at him. When Jemmy was fighting the monkeys, he would stand on his hind-legs and show his lovely white, carnivorous teeth at them, turning up his sharp, mole-like nose in a most contemptuous manner, all the time keeping up a continuous bark, into which fun the parrot generally entered and barked like Jemmy also.

One morning, in the middle of the fight, Jemmy forgot himself for the moment in turning round, and gave the ever-vigilant Little Jack a chance. Little Jack seized Jemmy's tail with screams of delight, and pulled him straight up to the bars. Carroty Jane then joined in, and they were getting the best of it, when suddenly Jemmy turned sharp round and made his teeth meet in Little Jack's hand. Little Jack skirmished round the cage three or four times on three legs; then, holding up his wounded hand, gazed mournfully and piteously at it, every now and then leaving off looking to make fiercer faces, and cock his ears at Jemmy. Never since has Little Jack ventured his hands outside the bars when a Jemmy-fight came on.

One of the funniest scenes that ever happened with Jemmy was as follows: Some seaside specimens had been sent me, and among the seaweed was a live shore-crab about the size of a five-shilling piece. Little "Chick-Chick," the marmoset, who will eat any quantity of meal-worms, blue-bottle flies, etc., came down at once off the mantel-piece and examined Mr. Crab, who was crawling about on the floor. None of my animals had evidently seen a live crab before. The monkeys were very much frightened, and made the same cry of alarm as when I show them a snake or the house-broom. Chick-Chick evidently thought that the crab was a huge insect. The crab put out his two nippers at full length, and gave the marmoset such a pinch that he retreated to the mantel-piece, and from this safe height gazed down upon the still threatening crab, uttering loud cries of "Chick, chick, chick!" alternated with his plaintive, bat-like, shrill note. Presently round the corner comes Mrs. Cat. The cat evidently thought that the crab, which was gently crawling about, was a mouse. She instantly crouched, head, eyes, and ears all intent, as if trying to make up her mind whether the crab was a mouse on which she ought to pounce or not. Hearing the row caused by the crab and marmoset fight, up comes Jemmy in full cry, with tail cocked well in the air. He also attacked the crab, but could not make head or tail of him. He did not like the smell, still less did he like the sundry nips in the nose that he received from the crab's claws. Jemmy has teeth half carnivorous, half insectivorous. When he is at home in Africa he lives upon mice, beetles, etc. He probably digs these creatures out of the ground, for, whenever he sees a crack in the floor, or a hole in a board, he will scratch away at it, as though much depended upon his exertions. When he is fed, it is curious to observe how he always pretends to kill his food before eating it. He invariably retreats backward while he is scratching and biting at his supposed lively food. The living food evidently is in the habit of escaping forward. Mr. Jemmy takes good care that he shall not do so, by scratching incessantly in a backward direction. A grand crab and Jemmy fight, which lasted nearly half an hour, then took place, ending in the discomfiture of the crab, whose carcass the marmoset and the cat, both coming forward, evidently desired to share. Although it was apparent that the taste of the crab was not agreeable to Jemmy's palate, yet he gradually ate him up, claws, shells, and all, simply to prevent the other animals from getting a single bit.

The cat's-meat man comes punctually every day at half-past one; when the cats hear the cry "meat," they rush down into the area, and Master Jemmy, seeing them bolt, would run also, his object being to steal the ration of meat from one of the cats. By instinct or experience he had somehow found out that the cat's claws are very sharp, and whereas his mode of attack upon the monkey was face to face, the monkeys being clawless, he attacked the cats by ruffing his hair up and pushing himself backward.

The cat, annoyed by being disturbed at dinner, would leave off eating and strike sharply at Jemmy with her paw; that was his opportunity. In a moment he would seize the cat's-meat and bolt with it, but by a most peculiar method, for when within striking distance of the cat's paw he would turn round and back up to the cat's face, and, directly she struck at him, he caught the blow on the back, then he would put his nose down through his forelegs, and through the hinder ones, and have the meat in a moment, leaving the cat wondering where it was gone. Jemmy had by this time taken it into a place of safety. Under the table in Mr. Searle's office there is just room for him to crawl; here the angry cat could not of course follow him. In this retreat he would finish up what he had stolen, and then emerge, licking his lips, and probably laughing to himself at the disappointed face of the cat. Jemmy was always fond of getting under anything or in any kind of hole, and his great delight was to get into a boot, and when he got to the end scratching it as though he wanted to get farther into the burrow. Frequently I found my boots going round the room, propelled, apparently, by some internal machinery. This machinery was Master Jemmy.

Jemmy was a greedy little fellow. John could not bring up any kind of food into my room without Jemmy. He would watch the cook broiling the chop down stairs, and when John brought it up would follow close to his heels, and what between Jemmy's pretty, begging manner, the monkey's plaintive cries, and the parrot's demand, it often happens that I get very little of the chop.

I had hoped to have written a fuller biography of our poor little Jemmy the Third, but alas! on Sunday last Jemmy was taken with a fit. I did everything I could to relieve the poor little fellow, but the fits were too much for him, and Mr. Searle and myself have been busily occupied in making his skin into a mat and his bones into a skeleton. The last Jemmy died of eating cotton-wool; this Jemmy died, I think, of eating too much, for he was as fat as a little bacon-pig, and weighed two pounds — a great weight for such a little animal. It is curious how fond I become of dear little animals such as Jemmy, and how much I miss his pretty little ways as I sit in the "Monkey-room" writing this memoir of my little pet.—*Land and Water.*

ON THE MIGRATIONS OF RACES.*

By FRIEDRICH MÜLLER.

IN endeavoring to subject this question to a brief examination, it must be previously understood that we only refer to those migrations which explain the distribution of existing and contemporaneous races and peoples, and such as can be deduced with some certainty from acknowledged facts. Neither will we consider migrations of individual races from some hypothetical ethnic center, nor those which many tribes have made that at present no longer exist. Except the aborigines of Australia, every people has undertaken migrations of greater or less extent, and many weighty reasons can be given to explain why the Australian has not ventured outside of his primitive abode. In the first place, from the very character of his country, through the absence of those animals and plants which contribute to enjoyment and prosperity, he had not raised himself to a knowledge of the pleasures of living incident to an advancing culture; and, in the second place, the country was itself large enough to contain the limited number of inhabitants, and to satisfy their simple wants. Whether the immediate neighbors of the Australian—the Papuans—have ever undertaken migrations is questionable; on account of the circumstance that they universally inhabit islands, and their dwellings built along the coasts resemble the pile-villages discovered in central Europe, it is easier to say they did migrate than to deny it. Yet the whole question is most intimately united to another, viz., Shall we consider that the ancient continent, of which the islands of the Indian Archipelago are fragments, was already peopled before its submergence, or were these separate islands successively occupied by expansion from some center?

None of the known races has undertaken so extended a migration as the Malayan. The distribution of this race from Madagascar in the west to Easter Island in the east, and from the Sandwich Islands in the north to New Zealand in the south, illustrates this. Notwithstanding its extent, this dispersion is traced from an ascertained point to the several islands as the traditions of each and the related character of the idioms of the individual branches unanswerably demonstrate.

Africa shelters at present five races distinct from one another, viz., the Hottentot in the extreme south and southwest, the Caffre, spread northward from the Hottentot, as far as and beyond the equator,

* Translated from the "Allgemeine Ethnographie," by L. P. Gratacap.

the negro races in the so-called Soudan, the Fellahs inclosed between the negroes and reaching from east to west in a straight line, and the central races spread from the north and northeast to the equator.

Of these five races, the first four only can be regarded as autochthonous, while the last, comprising well-established groups, migrated from Asia.

The Hottentots were formerly the exclusive inhabitants of south-easterly parts of Africa, from the Cape up to 18° or 19° south latitude. They were driven from their settlements by the invading Caffres streaming from the north, and at first were pressed back into the most southerly regions, and then later from this extremity northward along the west coast until they fixed themselves in the districts they now occupy. The northern neighbors of the Hottentots, the Caffres, are not aboriginal in the southern country, where at present they most numerously exist, but have immigrated here. They settled originally farther north, and stood in close relations for a long period with the Hamitic peoples, which migrated from Asia, as is clearly shown by their idioms. Since by reason of their type and intimate relationship they could not, for any length of time, have been separated by their primitive languages, which were continually approximating, they may have formed an individual group at the time of the invasion of the Hamites from the north into Africa; but they exhibit, in fact, so close points of resemblance with the Hamitic idioms that, without attributing this to direct contact, the coincidence appears inexplicable. Besides this *drift* from the north to the south, which is established from already ascertained facts, another from east to west diagonally across the continent was later instituted. From this circumstance it happens that the language of many stocks in the extreme northwest of the Caffre area show the most intimate relationship with those of the extreme northeast—a relationship not to be accounted for by a reference of both to the primitive tongue common to the Caffre or Bantu tribes, but completely through derivation from a branch of this original speech.

That the Fellah races are not aboriginal in those regions which they at present occupy is proved by their distribution among the negro races. Such a stratification of two races can not be aboriginal, but indicates distinct migrations of each. According to our view, the Fellah originally settled north of the negroes, probably in the territory now possessed by the Berbers, and pressed from the northwest into the land occupied by them, whence they spread toward the east to Nubia. This opinion is confirmed by the close relationship of the Fellah races with the central tribes, which appears to demonstrate an intermixture, as also by the many points of resemblance which the Fellah idioms offer to the Hamitic tongue.

That the individual peoples into which the negro race is divided have undertaken many migrations is at the very outset established by the great number of stocks, which are linguistically distinct, and of which only a few show any relationship with each other. Slavery may have contributed not a little to assist this dispersion, as that institution is by no means an invention of white men, but was long practiced by the blacks among themselves. It is not infrequent to see many negro tribes experience, through expulsion from their home, the same fate which among us overtook the Jews and Armenians.

These migrations of the four aboriginal races of Africa were not voluntary, but were pursued under the pressure of external circumstances. It certainly was owing to the immigration *en masse* of the central races, and especially the Hamitic stock, that compelled the aborigines of Africa to recede before their mentally and bodily superior invaders, and withdraw to the south of the continent. The inception of these emigrations is of great antiquity, and may be approximately described as follows:

The Egyptians were the last of the immigrated Hamitic stock, as we find them located immediately on the boundary of Suez, over which arm of land the migrations found their path. The accepted history of the Egyptians goes back four thousand years before Christ, at which time they had already erected a monarchical unit based on a highly developed culture. After allowing the shortest possible time for the Egyptians to have developed their culture from the rude beginnings to that height which is noticed in their monuments, viz., one thousand years, we find the year 5000 B. C. the latest date for their entry into Africa. Now, before the Egyptians, their relatives, the Berbers, with their collateral branch, the extinct Guanches, the Bedsha, the Somali, the Dankali, the Galla, and other tribes, wandered into Africa, and as ethnic movements are customarily slow and successional in nature, we may take one thousand years for the migration period. Thus at the lowest reckoning we reach the year 6000 B. C., from which we can date the movements of the autochthonous races of Africa.

As to the New World, according to our own view and that of other inquirers, at least two distinct races are represented, viz., the Esquimau in the extreme north, and the Indian distributed from the settlements of the Esquimau down to the extreme south. Other students take the ground that the type which we have named the Indian should be split up into many races, how many is not agreed. Whatever the facts in regard to this, all agree that the Esquimau is to be sharply separated from the Indian, and that he is not autochthonous in the New World, but a recent immigrant from the extreme north of Asia.

Among the Indian races, of whom only a few can be united linguistically in groups — as in respect to language the same heterogeneity prevails in America as among the negroes of Africa—still further migrations have been undertaken. These can easily be traced to their objective points. In North America such a point is the fruitful table-land of Mexico, toward which that stem, which in the north had attained among its kindred to a higher culture and greater strength, directed its victorious march. We find here many succeeding peoples of whom it is as yet not clearly shown whether they were fundamentally distinct, or in some particulars structurally related. The last of these invaders, the Aztecs, came from the north, and, as the language proves, are represented there to-day. According to the most recent investigations, the gigantic mounds which are found in North America are to be attributed to a people nearly related to the Aztecs of Mexico, and represent the rude precursors of the colossal structures of Central America. At any rate we must recognize in the northern division of the American Continent an *ethnic drift* whose direction was from north to south.

As to South America, the plateaux of Peru formed the destination of the migrations, as did Mexico in North America. Here also we encounter successive peoples, the last of whom—the conquering Incas—were found by the Spaniards on the discovery of Peru. Like the Aztecs in Mexico, the Quichuas were in no respect the originators of the indigenous culture, but have appropriated the same from a nation which preceded them. Although it is not improbable that the civilization of Mexico and Peru is at bottom congenital, as old elements of civilization could have been transported over the isthmus and on either side independently developed—in such a case the Muisca of Colombia might have formed the intermediate link—yet it is certain that the Mexicans and Peruvians were isolated, and as in the Old World with China and the rest of Asia, the one had no positive knowledge of the civilization of the other.

In regard to the two continents of Europe and Asia, which in fact form but one, inasmuch as the separation by the chain of mountains lying between them could not serve as an isolating boundary, we recognize, apart from the early Malayan, four autochthonous races, viz. : the Hyperboreans in the extreme north, stretching along the borders of the Arctic Sea ; the Dravida race, in southern India ; the Upper Asiatic race, filling central and eastern Asia ; and, finally, the midland races, which at present occupy the south of Asia from India westward, the northeast and north of Africa, and, with the exception of the extreme north and some spots in the middle and south, all Europe.

The Hyperborean race was formerly much more imposing than it is at present, reduced as it is to an insignificant remnant. They formerly settled farther south, and were pushed to the extreme north by the expanding Upper Asiatic race. The circumstance of finding in central Asia representatives of this race, though to be sure deprived in large measure of their national characteristics, confirms this. We refer to the Yenisei Ostiaks, together with other small stems which are philologically diverse from the Ural Altaïans, and presumably are allied to the Yukagiren, Koriaks, Tchuktchis, and Ainos.

The Dravida race once possessed all India from Cape Comorin to the Himalayas, and spread also across the Indus out to Beloochistan. Invaded by the immigrating Aryans, they were forced southward, until finally they contracted their limits within the southern half of the Indian Peninsula, the so-called Deccan.

That this race formerly reached so far northward as we have indicated is proved by the Brahuis in Beloochistan, whose existence in this country can only be accounted for by such an hypothesis. The beginning of the migrations of the Dravida race coincides with the appearance of the Aryan in the Punjaub and may be placed somewhere about the year 2000 B. C.

Central Asia must be considered the early home of the so-called Mongolian, more properly Upper Asiatic race. From this point this race radiated in all directions, but predominantly to the east and south. The leading people of this race, the Chinese, according to ancient traditions, came from the west into the great valleys of the Hoang-ho and Yang-tse-Kiang. But before them this region was already occupied by another people, as their vestiges, seen in the so-called Miao-tse, demonstrate. This stem is not, as we know now, a member of a distinct race, but only of a separate people, and is allied to the people of upper India, especially to the Thai. Thus, before the migration of the Chinese, itself hidden in a gray antiquity, there took place another migration of the aborigines of China belonging to this same race.

The inhabitants of Japan are also not autochthonous, but have immigrated from the west. They found on their settlement here natives who were, in their physical features, very distinct from the intruders. Indeed, the fact that in the southern districts the color of the skin of the inhabitants is dark, and their hair somewhat curly, points to a mixture with a darker race. It is not improbable that the Papuan race, whose existence on the Philippine Islands, and perhaps also on Formosa, has been established, diffused themselves originally as far as Japan.

The migration of the Upper Asiatic race to the west must have begun early, as we already find in the far past the Lapps and Finns in northern and northeastern Europe, peoples belonging to this race. It is not improbable that this race before the entrance of the Celts into Europe occupied the entire north and northeast, and possibly also a great part of central Europe. Many writers consider the people who used unpolished stone implements and weapons, found in northern and middle Europe, as being a branch of the Mongolian race.

Hence Europe may have been inhabited by only two races before the entrance of the Indo-Europeans, which latter is coincident with the appearance of the Etruscans and Celts, viz., by the Basques and Ligurians—a people of unknown ethnological character in the south, and the Upper Asiatic stems in the north. This settlement of the Upper Asiatic race in Europe, long before the immigration of the Indo-Europeans, presumes a migration of the former in the earliest dawn of antiquity.

In our opinion, it was this race which first gave the migratory impulse to the men inhabiting the Old World. The members of this race are well known to be almost exclusively nomads, whose support is derived from the abundance of their herds and the fertility of their pastures. It would only need one bad year, or a plague among their flocks, to constrain these powerful hordes to invade the territory of their neighbors and expel them from their lands. These latter were compelled in a similar manner to press upon *their* neighbors, whereupon the various tribes were set in motion upon every side.

If we regard the Indo-Europeans as neighbors of the Upper Asiatics, and the Semitic and Hamitic peoples next to them, we can understand how in consequence of a pressure of the Upper Asiatics on the Indo-Europeans these must again impinge upon the Semitic and Hamitic race. Whereas the latter were pushed toward Africa, where they imparted their migratory motion to the autochthonous races, as described above, the Semitic pressed into the seats occupied before by the Hamites, and allowed the Indo-Europeans room to expand unhindered east and west. Thus they in turn urged the Dravidas on one side into India, and on the other various tribes into Europe, compelling those migrations which we have briefly sketched above.

After this first migration of the Upper Asiatic races, which occurred before the commencement of the civilizations of China and Egypt, we encounter a second which originated those commonly known ethnic movements which can be more closely followed, as they fall within the historic period.

In consequence of this migration, the Hungarians and Osmanli reached the grounds occupied by them, and there was caused, through the entrance of the Germanic and Slavic peoples into the heart of Europe, that intermixture in consequence of which the Roman people arose, and the various Germanic and Slavic tribes attained their marked individuality.

As to the last of the races, the central or midland, it appears that their primitive seats should be looked for in the Armenian highlands. The migration from this center of the four branches of this race, viz., the Basques, the so-called Caucasians, the Hamito-Semites, and the Indo-Europeans, can thus be easily understood, though the displacement of this original seat farther east would certainly make the distribution of the Indo-Europeans, if not that of the other three, more comprehensible.

From the midland tribes the Basques first separated, turning toward the west, to Europe; the Caucasians followed, and their hordes, pushing to the north, found in the mountains of Caucasus a barrier which permitted them to extend their limits but slowly. The two remaining clans, viz., the Hamito-Semitic and Indo-Europeans, were for a considerable period neighbors, which is confirmed by the intimate correspondence of their religious and tribal traditions, so that, even after a separation, the Hamites and Semites yet formed an indissoluble unit. Their identity continued during the period of speech-growth, and was first lost when, through the pressure of the Upper Asiatic bands, the Hamites were sundered from the Semites, and were pushed on one side into the region bordering the Tigris and Euphrates, and on the other into Africa.

As we have already considered the immigration of the Hamites into the north of Africa in reviewing the peoples of this continent, there only remain to be examined the Semitic and Indo-European stocks.

Everywhere where the Semites appear we find them successors of the Hamites. It is so in Mesopotamia, in Palestine, in north Africa, presumably in Arabia, as it would seem from the dialects retained in south Arabia, entirely distinct from the Arabian tongue, and, lastly, in Abyssinia, a settlement effected from southwestern Arabia and across the Red Sea. In most places the Hamitic cultus disappears, ethnologically speaking, in that of the Semites, only leaving traces of its influence behind in the national characteristics. So in Mesopotamia, in Palestine—the Phœnicians are, for instance, Semiticized Hamites—in Abyssinia. And only when we know that the inhabitants of Mesopotamia are Semiticized Hamites is the harmony or coincidence of the Assyrian-Babylonian culture (Semitic) with that of the Egyptian (Hamitic) explained.

As regards the Indo-Europeans, we have first sought their aboriginal center about the sources of the Oxus and the Jaxartes, on the table-lands of Pamir, presumably because this point is nearest to the homes of two of the most easterly removed branches of this stock, viz., the Iranians and the Indians, and both these people certainly entered their territory from the northwest and northeast. But of late it has not unreasonably been insisted that the vocabulary of the Indo-European affords no evidence which intimates an acquaintance with the fauna and flora of Asia. On the contrary, the names of most trees known to all the Indo-European peoples, as birch, beech, oak, point rather to eastern Europe than to Asia. Therefore many authorities incline to locate the primitive home of the Indo-Europeans, or that point where they last composed an homogeneous unit, in the Lithuanian-Russian plains, or even farther west.

When, in conformity with this view, which has a very strong likelihood in its favor, we assume the original center of the Indo-Europeans to have been in southeastern Europe, then we can not but regard them as autochthonous at this point, yet as having first reached here from the Armenian highlands in the indefinite past. We are driven to this hypothesis by the racial unity of the Indo-Europeans with the Hamito-Semitic and Caucasian stocks, for it is impossible for both to have emigrated from the west into the highlands overlying Mesopotamia.

As is known, the Indo-Europeans are subdivided into eight groups, viz., Indians, Iranians, Thracian-Illyrians—whose fragments may be identified with the modern Arnauts, Albanians, or Skipetars—Greeks, Italians, Celts, Slaves, and Germans; which, again, according as they were earlier or later sundered from the common tree, or have among each other formed a single society a longer or shorter time, separate into subordinate groups. A. Schleicher, who has with especial assiduity pursued this inquiry, conceives in the first place that the Indo-Europeans split into two groups, viz., Germanians and Slaves on one side, and Aryans (Indians or Iranians), Greeks, Italians, and Celts on the other, whereby the Thracian-Illyrians are numbered among the Greeks. Later, on one side, the Germans divided from the Slaves, on the other the Aryans from the remaining three stems, and then that group in the same way disintegrated.

Many weighty considerations oppose this view of Schleicher's, and we shall permit ourselves briefly to explain our theory, which rests upon a careful examination of these very facts. According to our view, the Thracian-Illyrians first broke away from the common stock and withdrew southward, where they took possession of the Balkan Peninsula and the coasts along Italy. Later the original body split into two parts, viz., on one side the Celts, Italians, and Greeks, on the other Aryans, Slaves, and Germans. Thereupon the Celts separated from the first group, going westward, while the Italians and Greeks yet remained together for some time; in the same way the Germans separated from the Aryans and Slaves, turning northward. Finally the Italians parted from the Greeks, and the Slaves from the Aryans, which on their side again divided into Iranians and Indians. But, in spite of this concentric diffusion, many nations maintained an intimate union, as the Italians and Greeks, the Iranians and Indians, the Slaves and the Germans, whereby many points of contact in the social habits of these peoples were instituted. These resemblances, secured after the primal separation, are not to be confounded with the fundamental features held in common and extending back anterior to their subdivisions.

After this briefly outlined family tree of the Indo-Europeans, the peoples embraced therein undertook important migrations. There was an easterly migration of the Iranians, to whom belong the modern Persians, Kurds, Ossets, Armenians, Beloochees, and Afghans, and among whom in ancient times most of the peoples in Asia Minor were numbered, as the Phrygians, Cappadocians, and the Indians who at present occupy the peninsula of India from the north to the Deccan, with the exception of the territory in the mountainous interior. Far west and southwest the Celts first spread, when they came upon the Basques and Ligurians and ousted them; later came the Italians, spreading themselves from their peninsula outward, through the triumphs of Roman arms; over the whole of southwest Europe, invading the Celts;

and finally appear the Germans and Slaves, the two mightiest peoples of to-day.

In conjunction with these migrations of races, widely extended wanderings are apparent among the related divisions of the central or midland races, and especially of the Semites and Indo-Europeans, which wanderings are conjoined with the sad fate of the peoples concerned.

The fate of the Jews is well known, at present scattered over the whole world as traders and bankers. The Phœnicians played the same *rôle* in antiquity as the Jews in modern times; we find them everywhere at that time, wherever the country was open to commerce. The Armenians, among the Indo-Europeans, may be compared with the Semitic Jews. The migrations of the Armenians, who like the Jews have no particular fatherland and in great measure live by traffic, are in no way behind those of the Jews; besides, the history of both people has a great resemblance, as in large part their movements have been the result of religious persecution.

A people who have migrated widely are the notorious gypsies. According to their descent, the gypsies, who call themselves Roman, are Indian. They speak an idiom which finds a relative in the present dialect of India—the Enkelinnen of the noble Veda tongue. Indeed, there is impressed on this idiom a mixture of foreign elements from all the tongues of Asia and Europe, through whose areas the fugitives passed. We find in it Persian, Armenian, Greek, Magyar, Slavonic, German, and Roman terms, and increasingly as we follow the jargon westward. In every country that the gypsy has reached, he has picked up morsels and incorporated them in his own idioms. But these very philological fragments are of the greatest value to the student, as they surely indicate to him the road which the fugitive from the far East has pursued in his migration.

VACCINATION IN NEW YORK.

By R. OSGOOD MASON, M. D.

THE question of the usefulness and safety of vaccination as practiced in the principal cities of the United States is fairly settled. The general voice pronounces it both safe and useful. A small minority only of the intelligent refuse to acquiesce in the verdict, and comparatively few among the ignorant now refuse to test its benefits. In Europe, notably in England and Germany, the same can not be said. It is among the German population that even here the greatest prejudice exists, and in England there is at the present time a controversy going on, growing out of efforts to extend and enforce a compulsory vaccination law, which opens up all the old issues and affords opportunity for sending broadcast statements of the most sensational and mischievous character. These have recently been collected by a well-known *littérateur* and forwarded as a newspaper letter to this country, where, on account of their startling and sensational character, they have been somewhat widely copied.

It is charged in these statements—

1. That several terrible diseases, such as syphilis, cancer, consumption, and scrofulous diseases generally are widely scattered and communicated by vaccination. One vaccinator of twelve years' experience is made to say, "If I had the desire to describe one third of the victims ruined by vaccination, the blood would stand still in your veins." Another, "I have seen hundreds of children killed by it." A medical journal is quoted as saying that consumption has widely spread since the introduction of vaccination; which is very likely also true as regards lawn-mowers and pedestrian matches. A physician to the London Cancer Hospital declares that many of the cases of *cancer* treated at that institution originated with vaccination! A physician testifies before a Parliamentary committee that eleven out of thirteen children whom he vaccinated became syphilitic. Another declares that a large proportion of apparently inherited syphilis is really imparted through vaccination. A large number of cases of various kinds are cited with full and harrowing details, some of which have been subjects of discussion in medical circles during the past twelve or fourteen years.

2. It is charged that vaccination does not protect its subjects from small-pox. It is pronounced "not only an illusion but a curse to humanity"; "The greatest mistake and delusion in the science of medicine"; "A fanciful illusion in the mind of the discoverer, devoid of scientific foundation." It states that, out of 22,000 cases of small-pox treated in five London hospitals in five years, 17,000 had been vaccinated; and, furthermore, that, since compulsory vaccination had been established, the death-rate from small-pox had more than doubled. Such, in brief, according to these very remarkable statements, have been the results of vaccination in England, and it is in contrast with these statements that the results of vaccination as practiced in the city of New York are here presented.

Previous to the epidemic of small-pox in 1874–'75, vaccination had been fairly practiced, but in the same loose and unsystematic manner as was formerly the custom everywhere. Some physicians vaccinated the children of the families in which they were medical attendants and some did not. Vaccination was performed free to those who desired it at all the dispensaries, but no special care was taken to see that all the children in the several districts were vaccinated. Some physicians exercised skill and judgment in collecting the virus and doing the work of vaccination, while others were careless and slovenly.

There was no uniformity, no general supervision, and no responsibility.

In the autumn of 1874, notwithstanding some special attention was given to the matter, the number of cases of small-pox increased so rapidly, and the number of unvaccinated persons was found to be so great, that it was evident some more effective means must be adopted to meet the danger of a great epidemic. It was at this time that a permanent corps of vaccinators was organized under the charge of Dr. James B. Taylor, "Inspector of Vaccination," and under the general management of the Board of Health. The object of this corps was to visit systematically throughout the city, especially among the tenement-house population, offering free vaccination to all, and urging its advantages and even its necessity, in view of the epidemic character of the disease then prevailing.

During the following fifteen months ending in December, 1875, fifty-eight different physicians were connected with the corps, and an average of seventeen were constantly employed during that whole time. During this period, over 126,000 vaccinations were performed, all of which, so far as possible, were carefully watched and studied by competent medical men, not only for immediate practical results but also for the purpose of scientific deductions.

The method of procedure was as follows: It was important to commence the work with pure virus. Among those who had been interested in the careful study of vaccination here in New York was the late Dr. Jonas P. Loines, for many years house physician to the Eastern Dispensary. Twenty years earlier he had secured from abroad what was considered the best and purest virus to be obtained in any country. The use of this virus he personally superintended, and its results were carefully watched. It was kept separate from all other, and had proved protective and thoroughly satisfactory. This was the virus first used by the newly organized Vaccinating Corps.

At first no separate districts were assigned, but those localities most threatened with small-pox were sought out, and particular streets, blocks, or houses were designated for special attention. Later the city was districted and thoroughly canvassed. Each vaccinator made semi-weekly returns of his work to the inspector. These returns were on printed forms which required the name and address of the patient, whether front or rear house, number of room, age, nationality, parentage, and whether a primary or revaccination. At the inspector's office all these reports were carefully classified and recorded for future reference, primaries being kept separate from all others.

On the eighth day every case of primary vaccination was visited by a member of the corps specially qualified for the work, to observe the character and condition of the vesicle, whether perfect or in any way deficient, to revaccinate any cases of failure and to collect virus from perfectly healthy infants presenting perfect vesicles. All vaccinations not considered perfect, even though they had to a certain extent "taken," were either immediately revaccinated or the parents informed that the protection was not perfect, and advised to have the operation repeated at an early date. This work was also reported to the inspector, and the revaccinated cases again visited on the eighth day.

Between the twentieth and thirtieth days each case of primary vaccination was visited a second time to make sure that all was right, and deliver certificates of vaccination. If any unusual symptoms had occurred or the sore was tardy in healing, the case was taken in charge and treated until well. But even here the care did not cease. In each family where vaccination was performed a circular was left, printed in English and German, giving directions for the care of the vesicle, and directing parents to bring their children to the inspector's office at any time afterward, should any unpleasant effects appear which they might attribute to the vaccination—a privilege which they were not backward in claiming.

All the schools, institutions, asylums, workshops and factories were visited and vaccination offered. Two physicians were assigned specially to the public schools and the same care regarding reports, records, and revisiting was observed. Certificates were also given to those thoroughly protected in order to avoid the annoyance and labor of unnecessary examinations.

Thus the work of vaccination was for the first time carried on in a thorough and systematic manner, and thus it has been kept up ever since. Twice a year the tour of inspection and vaccination is made throughout the tenement-house region, factories, and all places where people are habitually brought together in large numbers in a more or less confined atmosphere. The schools are thoroughly canvassed about once in three years. Five years of such extensive, systematic and thoroughly studied work could scarcely fail of results of some kind either for good or for evil. During that time 270,970 vaccinations were performed by the Vaccinating Corps alone, independent of the great number performed at the dispensaries, and by physicians in their private practice. It remains to examine these results as regards the protection which vaccination affords against small-pox, and as regards the transmission of disease, which has constituted the great ground of prejudice against the practice of vaccination. Regarding the advantages or disadvantages of vaccination two main points present themselves :

1. Is vaccination a protection against small-pox?

2. Is it a vehicle for the communication of other diseases? Let the facts themselves speak ; and the facts here presented, all of which occurred during the epidemic of 1874–'75, are drawn from the published reports of the Board of Health and from personal conversations with Dr. Taylor, the very efficient Inspector of Vaccination, whose excel-

lent judgment and ample experience entitle both his facts and opinions to great weight.

I. Concerning protection. 1. In a large tenement-house in East Third Street were nine German families. An unvaccinated child was taken sick with small-pox, and the case was kept secret until the child died. All the other people in the house were vaccinated except one family consisting of parents and three children. The parents did not believe in vaccination and persistently refused it for their children. All three children had small-pox and two died. No other cases occurred in the house.

2. The inmates of No. — East Eleventh Street were exposed to small-pox. The vaccinators found three babies whose parents refused to have them vaccinated. Within three weeks all three children died of the disease. There were no other cases in the house.

3. No. — St. Mark's Place. Three cases of small-pox had already occurred in the house. The inspectors found three unvaccinated children, but vaccination was refused. The two eldest children took the disease; the youngest was already dying of marasmus. No other cases occurred.

4. At No. — Tenth Avenue was a concealed case of small-pox already of twenty-one days' duration. He had been vaccinated in infancy, but not since. He died before he could be removed. His wife and four children had been successfully vaccinated just before the husband took sick, and, though they had all slept in the same room with this fatal case of small-pox twenty-one nights, not one of them took the disease.

Cases of this character, where the unvaccinated were selected and attacked by the disease, while the vaccinated, though equally exposed escaped, could be multiplied almost without limit. Here is one from the inspector's own experience:

Small-pox was in a tenement-house of eighteen families. Most of the inmates submitted to vaccination, but two children were found upon one floor and three upon another whose parents refused to allow it, though repeatedly urged. Within a short time all five of these children had the disease and three died. The parents of the three unvaccinated children had a fourth child who had been successfully vaccinated at school, and for which she received a severe beating at the hands of her father. This child, although sleeping in the same room with those who were sick and dying of the disease, entirely escaped.

No more striking examples of protection afforded by vaccination could exist than that furnished by placing infants on the first day of their vaccination in a small-pox hospital, filled with patients in every stage of the disease. This was frequently necessary during the epidemic, where the mother was attacked, and the infant must accompany her to the hospital; and, says the inspector, "not a single instance has occurred where the infant so exposed has contracted the disease," even though the infant nursed the mother throughout the illness.

Experience has abundantly proved that, when babies *not* vaccinated are so exposed, the result has *invariably* been directly the opposite. In fact, the evidence in this matter is so abundant and of so conclusive a character that all who have taken the trouble to observe or study it during the past five years must be convinced that *perfectly vaccinated persons are absolutely protected from small-pox*, at least to the same extent as if they had already experienced the disease.

Why, then, it may be asked, do vaccinated persons have the disease at all? Simply because, in order to have the protection perfect, the vaccination must be perfect; and to this end two things are absolutely necessary: 1. The primary vaccine vesicle must be of proper size and character, and must run its proper and normal course. 2. Revaccination must be performed at proper intervals, namely, within five years after the primary, and again soon after puberty in those who are vaccinated in infancy, and at least one revaccination in those whose first vaccination was after maturity.

It is here that the great fallacy of statistics upon this subject is found; and this is why the English statistics before quoted show that, out of 22,000 cases of small-pox treated in the hospitals, 17,000 had been vaccinated. They had been vaccinated in infancy—perhaps properly, perhaps improperly—but in all probability had never been revaccinated. It should be once for all understood that, in order to have full protection, revaccination at the proper periods is just as necessary as the original vaccination.

It should be understood that a primary vaccination is not expected to protect for a long series of years, but only for a few years; and that after a limited time, although it may modify more or less the severity of the disease, it ceases to be absolutely protective, and must be renewed.

Statistics, however, show that, of persons attacked with small-pox, from three to four times as many deaths occur among those who have not been vaccinated at all as among those who are reckoned as vaccinated, though it may have been only in infancy. They also show that such vaccinations are nearly worthless as protection against small-pox after several years have elapsed, and very uncertain even in their power to modify the disease.

II. Concerning the transmission of other diseases by means of vaccination.

It may be presumed that if bad results of any kind were to follow vaccination, it would happen in primary cases, where the virus exerts its full influence of every kind. It has been seen with what care all these primary vaccinations have been watched during the past few years, the oversight extending even beyond the perfect healing of the arm. A circular was left in each family, requesting that any unfavorable symptoms which might subsequently arise, apparently as the result of vaccination, should immediately be reported to the inspector at his office. As a consequence of this invitation quite a number of complaints were received, every one of which was thoroughly investigated. It is fair, therefore, to suppose that every case of importance thus came under the observation of the inspector. Out of 24,395 primary vaccinations, 145 complaints were entered—scarcely more than one in 150 cases. On examination these were divided into four classes :

1. Ulceration and sloughing of the arm about the sore.
2. Inflammation and erysipelas.
3. Inflammation of the neighboring glands and sometimes abscess.
4. Various eruptions on the skin.

Two deaths occurred, both from erysipelas. Both these cases were in bad subjects, one being complicated with meningitis, the other being in a poor anæmic child with "such miserable surroundings as to preclude the possibility of recovery." In such subjects any operation, even the slightest, or any accident, an ordinary cut or bruise, without inoculation of any kind, is liable to be followed by most serious results. The vaccine virus can not be held responsible for the mischief in these nor any of the cases complained of, since in the same streets, even in the same houses, many other children were vaccinated with the same virus with perfect results. The fault was in the children themselves, their parentage, their constitutions, their habits and surroundings. So true is this that, if vaccinators could choose their cases, avoiding all bad or doubtful subjects for the sake of avoiding the prejudice aroused by a single unfavorable result, seldom indeed would a complaint be entered ; but, on the other hand, many a child fairly entitled to the benefits of vaccination might be left unprotected. These results are mentioned, however, that nothing may be covered up which was actually found as a sequel even if not a result of vaccination.

Looking for statistics or even single cases of disease actually transmitted from one person to another by means of vaccination, no such cases exist. Concerning syphilis the inspector says, "Among all the cases of bad results which we have seen, we have failed to find a single one showing any indications of syphilitic inoculation, nor have we ever met a case of this kind in all our experience." Only a very few such cases have been brought to notice as even suspected, and none which would bear investigation. They were either not syphilis at all, the most usual result of examination, or else showed some other and more probable way of receiving the infection.

But what of other terrible diseases—cancer, consumption, and all the other forms of scrofula—for which vaccination has been blamed? No such cases have ever been brought to the notice of the inspector. The idea that such diseases can be so transmitted is absurd on its face, since it is certainly most difficult, if not utterly impossible, to reproduce any of them by any process analogous to that employed for vaccination.

All these reports and facts relate to vaccinations performed with humanized lymph, and previous to 1876. The most careful examination of every reported or suspected case among the 126,000 vaccinations performed up to that time failed to furnish a single case of the transmission of disease of any kind whatsoever from one person to another by means of vaccination.

In order, however, to avoid as far as possible the prejudice which was at one time so widespread in this matter, no humanized lymph has been used by the Vaccinating Corps for nearly three years. All the virus now used is eighth-day lymph taken from healthy calves carefully selected and kept in the country under the supervision of the inspector, exclusively for this purpose.

No very special advantage is claimed at present for this over properly selected humanized lymph; if, however, any difference is observable in the results, it is in favor of the bovine lymph, as affording fewer cases of troublesome inflammation.

One advantage is decided: it has tended to diminish a prejudice, and so remove in some degree an objection to vaccination.

It is in the face of an abundance of facts such as these, instead of the badly observed and badly studied facts of fifteen years ago, that intelligent people now must doubt the safety and utility of vaccination.

THE MOST POWERFUL TELESCOPE IN EXISTENCE.

By E. NEISON, F. R. A. S.

WHICH is the most powerful telescope in existence? Define the meaning which ought to be attached to the adjective "powerful" in this question. The most powerful telescope in existence is that existing telescope which can do the most work. The work of a telescope may be said to be to enable you to see and to enable you to measure. Therefore, that telescope with which you can see most and can measure best is that which can do the most work, and is unquestionably the most powerful telescope in existence.

Which is the most powerful telescope in existence?

Every one has heard of the two giant telescopes which were constructed nearly forty years ago by the late Lord Rosse, and which were erected at his residence at Parsonstown, about fifty miles from Dublin. The first great telescope constructed by Lord Rosse was a reflecting telescope with a speculum three feet in diameter and twenty-six feet in focal length. It was carried in a ponderous tube moving in a massive iron mounting by means of ingenious machinery. When it was finished in the year 1840 it was considered the grandest instrument in existence, and from its employment in the study of the heavens enormous advantages were expected to be gained for astronomy. Scarcely, however, was this telescope out of the hands of its maker, than Lord Rosse resolved to construct a second telescope of still larger dimensions. With enormous skill, patience, and ingenuity Lord Rosse carried out this intention, and by the year 1846 had finished his second grand telescope, the instrument commonly known as "Lord Rosse's Telescope." It has a metal speculum six feet in diameter and fifty-four feet in focal length. This enormous mirror, which weighs nearly four tons, is placed in a great tube eight feet in diameter and fifty feet in length, and this tube is carried by a massive iron mounting supported by two lofty castellated buildings, each nearly sixty feet in height. The weight of the telescope and its mountings is enormous. By ingenious methods the observer who is using the telescope is placed in a kind of cage, suspended in the air from the mounting of the telescope, and carried up and down along with the instrument.

To this day this giant telescope of Lord Rosse's retains its position as the greatest telescope in existence. In its enormous size it has still no rival, in its massiveness and weight it is long likely to retain its preëminence.

Which is the most powerful telescope in existence?

Lord Rosse's giant telescope, of course, will be the answer of most people; it will be the answer of the great majority of scientific men; it would be almost the unanimous answer of the British Association, of that Section A which is supposed to keep the world informed of the great achievements of astronomy and of optics.

Is this the true answer? No.

To most people, to most scientific men, this answer will come like a shock, for to them it has long been a cherished tradition, an article of faith, almost an axiom, that Lord Rosse's giant telescope was the most powerful telescope in existence. To those astronomers who are observers, astronomers not star-gazers, it is well known that for years this giant telescope of Lord Rosse's has been beaten in power by far smaller and more compact rivals. In fact, it is doubtful whether in real power it is much superior to its smaller companion, the three-foot telescope.

There are many who judge a telescope by its size alone, who compute its excellence by aid of a two-foot rule, and a knowledge of its cost in pounds. With them a telescope with a metallic speculum weighing four tons and measuring six feet in diameter, with a tube fifty feet long, and costing a thousand pounds, ought to give so much light, have such and such separating power, and show this or that object. It is true with small telescopes a great deal may be done in this way, but experienced observers know that the real power of a telescope can only be ascertained by a study of what it has done. Tried by this test, the giant telescope of Lord Rosse breaks down. It has not the accuracy of definition which constitutes the real power of a telescope, for it is mainly upon this that depends its capability for doing work. Compared with the metal specula which were made at the time when Lord Rosse's telescope was constructed, the great speculum of Lord Rosse's instrument might come out with credit. But great improvements have since then been introduced into the manufacture of reflecting telescopes, and the present silver-on-glass reflecting telescopes successfully rival the finest achromatic telescope in definition and in power.

In days gone by repeated reference was made to the wonderful things which could be seen upon the surface of the moon with these two giant telescopes of Lord Rosse's. Picturesque descriptions were given of the minute features which were visible; amazement was often expressed at the small objects which could be seen. Still more interesting accounts were given of what *ought* to be visible—a carpet of pronounced pattern as big as Lincoln's Inn Fields, the Castle at Dublin, the Court-house at Cork, a house, or even a man, provided he were big enough. All these *ought* to be seen if they happened to be on the lower surface. Yet when we come to consider what it really is which is described as being seen, when we calmly examine the various drawings which have been made by the aid of one or the other of these great telescopes, then we find that they show nothing which can not be distinctly seen and drawn by the smallest astronomical telescope of high excellence. An enormous blaze of light is gathered by the telescopes, but all this light reveals nothing which can not be seen with far greater ease in a far smaller telescope. There are in existence a number of drawings of the planets, and observations of their satellites; there are also observations of close double stars, or faint companions to bright stars, all made with one or the other of these two telescopes. Yet nothing has been seen which is beyond the power of a good astronomical telescope of comparatively moderate aperture. It is only in observing the dull, ill-defined nebulæ that Lord Rosse's great telescope has any exceptional advantage, though even in this respect it is probably much overrated. As an astronomical telescope either of Lord Rosse's telescopes would be fairly beaten by either of the fine eighteen-inch reflectors which are now in existence.

If, then, Lord Rosse's great telescope is not the most powerful in existence, what answer is to be given to the question with which we commenced? Which *is* the most powerful telescope in existence? There are the great refractors of Poltava and of Cambridge, United States, each of fifteen inches in diameter and twenty-three feet in focal length. There is the still larger refractor of Chicago, with an aperture of eighteen inches and a focal length of twenty-three feet. All these instruments are of high excellence in defining power, the essential point where Lord Rosse's breaks down. There is the reflector of Mr. Lassells, with its metal speculum of two feet in diameter and its tube twenty feet in length. There is the great Melbourne reflector, with its great metal speculum of forty-eight inches in diameter, the second largest telescope in the world, but by no means so sharp in definition as might be desired, so that it failed to reveal the satellites of Mars which were seen with an instrument of not one sixth the diameter in Europe.

There is also the great reflector of the Paris Observatory, with a silver-on-glass speculum nearly four feet in diameter, an instrument whose power is seriously injured by the imperfect definition arising from the flexure of its thin speculum. There is also the large refractor constructed for Mr. Newall, of Gateshead, with an object-glass twenty-five inches in diameter mounted in a tube nearly thirty feet in length.

But all these instruments must yield the palm to the great refractor of the United States Naval Observatory at Washington, a splendid instrument, with an object-glass twenty-six inches in clear aperture and thirty-three feet in focal length. This magnificent instrument is equatorially mounted and driven by clockwork, so that it is complete as an astronomical telescope. The Washington refractor is, however, not merely a telescope of great dimensions; like more than one of those previously mentioned, it is an instrument of high optical excellence. Its definition is crisp and sharp, and it brings every ray of the enormous amount of light which it collects to a sharp focus as a very minute point, so that none is wasted. It was with this fine telescope that Professor Asaph Hall made his famous discovery of the satellites of Mars, that Mr. Burnham discovered a number of the most minute companions to the brighter stars, and that Professors Newcomb, Holden, and Hall have observed and measured the smallest satellites of Saturn, Uranus, and Neptune. It is this magnificent instrument which is supposed by most astronomers to be the most powerful telescope in existence. Then our answer to the question with which we have commenced ought to be—the great refractor of the Washington Observatory. No!

Then which is the most powerful telescope in existence?

The most powerful telescope in existence is the magnificent new reflecting telescope which has been just finished by Mr. A. Ainslie Common, and is erected at his residence at Ealing. This telescope has a silver-on-glass speculum, thirty-seven and a half inches in diameter, and a focal length of just over twenty feet. It is equatorially mounted in a novel but most efficacious manner, and is driven by a powerful clock controlled in an ingenious manner by a method invented by Mr. Common. This new telescope, which has only been finished about a month, has turned out a great success, and is unquestionably the finest and most powerful telescope in existence.

For the last three years Mr. Common has had in his observatory a fine silver-on-glass reflector, with an aperture of eighteen inches and a focal length of nearly ten feet. This telescope was mounted by him on an equatorial stand of his own design, on what is known as the "Sissons" principle. For efficiency, power, and excellence this eighteen-inch reflector is as yet without a rival in England, and was only beaten, perhaps, by the great refractor of the Washington Observatory. With this instrument were made a number of observations of the faint satellites of Saturn and Uranus, which rendered the Ealing Observatory a familiar name to all astronomers. When, in 1877, the astronomical world was electrified by the announcement of Professor Asaph Hall's discovery of the two satellites of Mars, it was to Ealing that astronomers looked for systematic observations of these faint objects, and it was from Ealing Observatory that came the only systematic series of measures of these objects which has been furnished by England. Astronomers may congratulate themselves, therefore, upon this new telescope being in good hands, and in an observatory where it will not be allowed to rust in idleness like so many of the finest instruments in England.

Satisfied from the performance of his eighteen-inch Newtonian reflector that it would be possible to successfully construct much larger instruments of this kind, it seems to have been about two years ago that Mr. Common first seriously thought of constructing a very large reflecting telescope with a silver-on-glass speculum. It was obvious that this would be a serious undertaking, and one which would require much thought and ingenuity to carry it out successfully. Many difficulties would require to be boldly faced and successfully overcome. The expense alone would have been sufficient to deter most men. Experience, skill, courage, perseverance, money—all would be required if success was to be won.

It was decided to first undertake the manufacture of a telescope with an aperture of thirty-seven and a half inches and a focal length of about eighteen or twenty feet. This was a much shorter focus than had usually been thought essential for an instrument of this large aperture. Generally instruments of this kind are made with a focal length of from nine to ten times their diameter. This would correspond to about thirty feet focus for a speculum of the given size. The fine performance of his eighteen-inch telescope had convinced Mr. Common that it was not necessary to give a greater focal length than fifteen or sixteen feet. But there were two conflicting interests to be reconciled. The shorter the instrument the easier it would be to mount, and the easier to observe with; but, on the other hand, the longer the focus the better it would be for taking photographs of the heavenly bodies, and this last was one of the main uses that the new telescope was intended for. With the view of best reconciling these two views the instrument was designed with a focus of some twenty feet.

The very first step to be taken was to undertake the manufacture of the glass speculum, and here at the outset an enormous difficulty presented itself. To make a speculum of the required dimensions it was necessary to have a disk of good crown glass about thirty-eight inches in diameter and from six to nine inches in thickness. Well, purchase such a disk; or rather, as it was not likely that such a thing could be bought ready-made, why order one. This seems feasible enough. But there was not a firm in England who would undertake to make such a thing. In fact, at the time, the opinion was freely expressed that such a thing could not be made. This was a serious obstacle, for nearly all the glass used for optical purposes came from England. Determined not to be baffled, Mr. Common applied to a French firm, and they produced the disk of glass which was essential before a single step could be taken. The first difficulty was faced and overcome.

After mature consideration the grinding and polishing of the speculum into which this glass disk was to be turned was intrusted to Mr. G. Calver, of Widford, a well-known maker of glass specula. From its enormous size, over twice as large and ten times as heavy as any speculum which had ever been manufactured before, it was necessary to construct new and more powerful machinery and even a new building. Nothing daunted, however, Mr. Calver agreed to do his best to turn this great mass of glass into an excellent speculum, though of course he could not guarantee anything, the entire risk necessarily remaining with Mr. Common.

This settled, the greater portion of the task remained to be faced. Given a speculum of the specified size, how was it to be mounted, and how was it to be used? 1. The glass speculum must be mounted with such care that, despite its enormous weight, it must nowhere bend by as much as one ten-thousandth of an inch. 2. The glass speculum and the iron cell which supports it must be fastened at the end of a tube some twenty feet in length, and this tube must be supported by an elaborate mounting by which it can be pointed to any desired part of the heavens, and moved by clockwork so as to follow the apparent motion of the celestial bodies. 3. Arrangements must be made so that an observer can always use the telescope, and be enabled to look through the eye-piece of the telescope whatever position it may be in—no slight task, seeing that the said eye-piece must in some positions of the instrument be over twenty feet from the ground. Lastly, the telescope must have an observatory which will shield it from the weather, and yet permit any part of the heavens to be examined with the telescope.

When the instrument has a metallic speculum, like the large reflecting telescopes of Lord Rosse and Mr. Lassells, and that at Melbourne, it is much easier to satisfy the first condition than when the speculum is made of glass; for it is possible to cast the speculum with grooves, projections, and recesses in its back, by means of which the task of supporting it is much simplified. With a glass speculum it is not practicable to have these aids, so that the back of the speculum is cast quite flat, and usually rests on a flat plate of metal. By an ingenious method of balanced arms Mr. Common has contrived to support the speculum so that it is perfectly free from flexure. Thus the first point was secured.

The second point, or the method by which the telescope should be mounted, was a problem which required long and serious consideration. Mr. Common devised a new and most ingenious method, which, after long consideration, he thought would furnish a means of steadily supporting the telescope. In this steadiness is most essential, the slightest vibration, vibrations absolutely invisible to the eye, would ruin the performance of a telescope. The weight of the moving part of the telescope amounts probably to four or five tons, and this has to be kept in motion by a clock, yet it must not be liable to the least tremor or vibration. The difficulty of the problem is evident. His plan of a mounting was submitted by Mr. Common, for criticism, to several well-known astronomers, who might be supposed competent to advise on this subject. As might have been expected, very diverse opinions were expressed ; at most, one seemed to decidedly favor the plan, others seemed doubtful, and more than one were decidedly adverse. The result was, to leave that matter much as it stood at first, so that Mr. Common decided to persevere in his original design. The success which has crowned his labors shows that he was correct in his judgment. It would be impossible to describe the method of mounting employed without the aid of several detailed drawings, but reference may be made to one ingenious point. As in all equatorial mountings, nearly the entire weight of the moving part of the telescope (in the present telescope five tons) rests on the bottom pivot of the polar axis. This pivot, therefore, is exposed to enormous friction, and is a common cause of vibration. To obviate this, Mr. Common, by an ingenious arrangement, supports the whole polar axis in mercury, thus taking off nearly the entire friction, and the whole instrument moves as if it were floating. By this means he is enabled to drive the whole telescope with an ordinary train of clockwork, regulated by the governor, which he had invented for his smaller telescope.

The last two points specified above are obtained by making the observatory itself the ladder by which you approach the eye-end of the telescope, and the whole observatory revolves on iron wheels running on a circular railway. By means of a wheel on your left, you can raise or lower yourself at pleasure, and observe with the telescope in any position. The whole observatory only requires moving about once in two hours, and can be moved with ease by one hand.

Within a year of its being begun, the telescope was rapidly approaching its completion. The great speculum had been brought to the right shape, and was partially polished, and every day the announcement was expected that it was completed, or at least only required the final finishing touches. Suddenly a telegram arrived—an ominous thing. Was it to announce an imperfect figure? This would be a most annoying thing, for it would require the whole to be reground and repolished. But no, it was very brief, but it announced a terrible misfortune. It was a pressing request to come down at once. *The whole speculum had burst into a thousand pieces.*

It was a terrible blow, for it was the very misfortune which had been prognosticated by the English manufacturers and by the greater number of astronomers, including those who had had much experience in the construction and use of specula. The explosion had been terrific. The whole workshop was covered with jagged, torn masses of glass, varying in weight from ten or twelve pounds to an impalpable dust. Mr. Calver had had a narrow escape, but he and his workmen escaped without serious injury. The monetary loss was great, and bade fair to be greater, for with the loss of the speculum the rest of the telescope became useless. It might well seem that they were right who held the view that large silver-on-glass specula were impracticable, as from the difficulty in annealing large masses of glass they might be expected to break at any moment.

Within an hour or two of receiving the telegram announcing this terrible mishap Mr. Common was in the library of the Royal Astronomical Society. While there he was met by a friend, a fellow astronomer, who, being aware that news was daily expected of the completion of the great speculum, asked him for the latest intelligence. Mr. Common calmly handed him the fateful telegram. He was thunderstruck, for it was so unexpected, and he was one of those who had looked for much gain to astronomy to accrue from the construction and subsequent employment of this grand new instrument. After expressing, no doubt imperfectly enough, his sorrow, sympathy, and disappointment, he naturally put the question, "What can you do now?" The answer came gently enough: "Do? Why, I have telegraphed over to Paris to see if I can't get two more disks of glass. It will be one to spare in case of another explosion."

Success must crown indomitable courage like this. The new disks arrived, and were duly transferred to Mr. Calver. One was selected, and, after much labor, ground, polished, and finished. The remaining portion of the instrument and the observatory were pushed on as quickly as possible. On August 1, 1879, the instrument was complete, and the grandest and most powerful telescope in existence stood finished before its maker, designer, and owner.

An instrument of this large aperture will take a long time to thoroughly test, but it has stood triumphantly all the tests which have been applied hitherto. It has been tested on the moon, a most crucial test in experienced hands, on Jupiter and Saturn, and on faint companions to bright stars. In all cases satisfactory results have been obtained.* This proves that the telescope must be at least of fine quality, and it bids fair to turn out of the highest excellence. It has been used to take photographs of the moon, with results very satisfactory to those who are experienced in these matters. There can be no doubt, therefore, of its claims to be a success, so that ere long it will take its place, in the eyes of most astronomers, as the greatest optical instrument in existence, and the credit of having manufactured and of possessing the most powerful telescope in existence has now passed from America back to England.

It may be legitimately asked, What will be the future work of this grand instrument? Will it be used to increase our knowledge of astronomy, or will it be allowed to rest in idleness like so many other fine instruments? It is to be trusted, and it may be safely anticipated, that the former will be its fate. It will wear out, not rust out. There is much in astronomy which this grand telescope can do. It can be used for observing the faint and difficultly visible satellites of Mars, Saturn, Uranus, and Neptune. All these pressingly want observing and measuring, and there are few telescopes of sufficient power and excellence to do the work wanted. It can be easily done with the new one. Then there is the important question to be settled, Are there other satellites to those planets than those known? To this telescope will fall the task of searching for a third and more distant satellite of Mars, for a fifth satellite to Jupiter, for a ninth and tenth satellite to Saturn, for a fifth and sixth satellite to Uranus, and perchance half a dozen new moons of Neptune. Moreover, there are the extremely interesting problems connected with the minor planets. Does Vesta, Juno, or Pallas, possess a satellite or satellites? If so, their discovery would be a great thing for astronomy. Astronomers suspect that away beyond Neptune there may be still another giant planet, still another member of the solar system. If so, it will be very faint, and it will require a powerful telescope to search for and discover it.

There is yet another field in which this new telescope may reap great advantages for astronomy. It is suspected that more than one of the stars, those distant suns, may be attended by opaque, dull planets. Mathematical analysis has already pointed to the existence of these attendants. It remains for the telescope to discover them. If the new Ealing reflector be really of the very highest excellence, it will be with that instrument we ought to look for these attending planets, these members of a foreign solar system.

Lastly, there is the great field of photography. The new telescope takes instantaneous photographs of the moon two and a half inches in diameter, photographs which can be enlarged with ease to good pictures of the moon a foot in diameter—pictures which will be valuable for astronomy, not mere interesting curiosities of science. It will,

* Lately this telescope has shown the outer satellite of Mars three weeks before it was thought possible it could be seen with the great telescope at Washington.

moreover, take photographs of Venus, Jupiter, Mars, and Saturn, showing much detail, and capable of being enlarged to half an inch in diameter. These planetary photographs will be of great use, as recording in unmistakable characters the true position and aspect of these planets and their satellites at different known epochs.

The foregoing sketch will show that in constructing this new instrument Mr. Common has contributed in a most important degree to the advancement of astronomy.—*Popular Science Review.*

THE MORAL SENSE IN THE LOWER ANIMALS.*

By W. LAUDER LINDSAY, F. R. S. E.

ALL the ordinary definitions of what is variously called in man the *moral sense*—sentiment, feeling, faculty, or instinct—apply, though not necessarily equally, in the same degree, with quite the same sense or force, to an equivalent mental attribute or series of psychical qualities in other animals, and which attribute or qualities in other animals there is no good reason for distinguishing by any other name, simply because they are to be found in animals zoölogically lower than man.

Thus the moral sense in man has been defined by different classes of authors to be, or to include—

1. A knowledge, appreciation, or sense of—
   a. *Right and wrong.*
   b. *Good and evil.*
   c. *Justice and injustice.*

2. *Conscience*, involving feelings of approbation or the reverse in relation to ideas of right and wrong.

3. The approval of what is conducive to well-being, and the disapproval of the reverse.

4. Sense of *duty* and of moral obligation.

5. Appreciation of the results of *honesty* and dishonesty.

6. Virtue or virtuousness, including especially such moral virtues as conscientiousness, scrupulousness, integrity, compassion, benevolence, fidelity, charity, mercy, magnanimity, disinterestedness, chastity, modesty.

There is not one of these moral qualities that is not possessed, sometimes in a high degree, by certain of the lower animals, and more especially the dog; and there are many authors, who have been desirous of drawing marked psychical distinctions between man and other animals, who have nevertheless felt themselves compelled by the evi-

* From advance sheets of "Mind in the Lower Animals." By W. Lauder Lindsay, M. D., F. R. S. E., etc. 2 vols. In press of D. Appleton & Co.

dence of facts to concede to these other animals, or certain of them, the possession of morality akin to that of man. Agassiz, for instance, grants them morals; Froude speaks of their principles of morality; Brodie refers to the moral sentiments as occurring in gregarious animals; Shaftesbury allows to them a sense and practice of moral rectitude; Watson gives instances of their moral feeling, and Wood of their conscience. And certain animals have even been described as possessing a moral law and codes of morals.

The dog, at least, frequently exhibits a knowledge of *right and wrong*, making a deliberate *choice* of the one or the other, perfectly aware of and prepared for the *consequences* of such a selection. The animal has occasionally the *moral courage* to choose the right and to suffer for it, to bear wrong rather than do it (Elam). Not only does this frequently noble animal know the right, but it dares to do it, enduring the expected, the inevitable, consequent suffering. One of the many evidences that the dog is sensible of right doing is to be found in the familiar fact that when it performs an action which to it seems meritorious, or which it has reason to believe its master will deem so—when it saves a life, or successfully defends a trust, or resists some great temptation—it looks at once for some sign of the said master's *approbation*, perhaps for some reward. There are both the self-approbation or self-satisfaction of the *mens conscia recti* and an expectation of man's approval. The animal is gratified if such approval is in any form vouchsafed, disappointed if it be withheld.

It must also distinguish between the right and the *expedient*—what would be most for its own interest to do. In other words, it is just as apt as man is, and not more so, to take a *selfish* view of all affairs—to consider how they are likely to affect its own personal interests. The choice that is finally made between the right, the expedient, and the wrong is determined by a variety of considerations—by conflicting emotions, by the balancing of probabilities and inclinations, by the degree or kind of temptation, by the presence or absence of witnesses, especially human, by other specialties of an animal's position, by the nature and extent of its moral training, by the character of the rewards and punishments offered on previous occasions. In the dog there is sometimes obviously the same kind of conflict and collision between virtue and selfishness, between a sense of what is *right*—which is too generally also what is painful, what calls for terrible self-denial and suffering, including the physical pangs of hunger and thirst, as well as the moral pangs, say, of unsatisfied revenge—and a sense of what is simply pleasant and profitable.

Temptation frequently begets in the dog, cat, and other animals the same kind of mental or moral agitation, and the same sort of result, as in man. Sometimes we can see—in the dog, for instance—the whole play of the animal's mind—the battle between its virtuous and vicious propensities, its promptings to the right and its endeavors to stick by the right, its longing for the wrong—for the titbit, which it knows it would be improper to steal—and the final triumph either of virtue or temptation. The poor animal, knowing or feeling the weakness of the flesh, sometimes has the moral strength, the force of character, the good sense, to *avoid temptation* altogether. But dogs, like men, are apt to have the most trying temptations thrust unexpectedly upon them, and then comes the tug of war of the appetites and passions—the moral turmoil that may make shipwreck of or that may strengthen virtue. Sometimes, then, by the dog, as by the man, temptation is successfully resisted after perhaps a series of protracted and painful moral struggles that have been very apparent to the onlooker. Unfortunately, however, equally in dog and man, the *resistance* of temptation is less common by far than non-resistance or non-success in resistance, the result of which is various forms or degrees of wrong-doing.

But in the dog, cat, and other animals this *wrong-doing* is accompanied by a perfect consciousness or conception of the nature of their behavior. They are quite aware of being engaged in actions that will bring inevitable punishment, which penalty, moreover, they are sensible they deserve. Miss Buist gives the history of a pet canary that was given to prancing about on her piano-keys, and that knew it was wrong in so doing.

Abundant evidence of a consciousness of *wrong-doing* is to be found either generally in the—

1. Pricks, stings, or pangs of *conscience.*

2. The various expressions of a *sense of guilt*—for instance, the—

   a. Sneaking gait.

   b. Depressed head, ears, and tail.

   c. Temporary disappearance.

   d. Permanent absconding; desertion of home and master.

3. The multiform exhibitions of *contrition*, regret, repentance, self-reproach, remorse—

Or more specifically in the—

4. Efforts at *reconciliation* and pardon, including the giving of peace-offerings.

5. Various forms of making *atonement.*

6. *Concealment of crime* or its proofs.

7. Artifices for *escaping detection* or conviction.

8. *Non-resentment of punishment.*

9. Sensitiveness to *reproof*, or even under mere reference to former delinquency.

10. *Punishment of offenders* by and among each other.

Conscience is frequently as severe a monitor in other animals as in man, its reproaches as stinging and hard to be borne, its torments sometimes intolerable. We may speak quite correctly, for instance, of the *conscience-stricken* animal thief, the cat or dog caught in the act of pilfering from the larder. The signs of detected and acknowledged guilt are the same in kind as would be exhibited under parallel circumstances by the human child. The animal, like the child, if rendered sensitive by previous moral training, shows unmistakably its consciousness of delinquency. Its look and demeanor alike eloquently bespeak its sense of detection and disgrace. It understands its master's accusation as conveyed by eye, tone, word, gesture, and it either makes instant effort to escape the punishment which it knows it has incurred and deserved, or, if escape be hopeless, it, as calmly as may be, awaits the said punishment, and does not resent it, as it would did it feel it to be unmerited. A bitch having once eaten a quantity of shrimps intended for her master's dinner sauce, had only to be asked ever after, "Who stole the shrimps?" to cause her to take to ignominious flight—ears and tail down—going to bed, "refusing to be comforted . . . . the picture of shame and remorse," while we are told "she never stole again" ("Animal World").

A young dog having committed some offense against the established rules of his master's household, "after we had shaken our heads at him and turned away . . . . although he must have been very hungry, would not touch his food, but sat close to the door, whining and crying, till we made it up with him by telling him that he was *forgiven* and taking his offered paw, when he ate his supper and went quietly to bed." Another dog, "if he has done anything wrong, comes up looking very much ashamed of himself and voluntarily offers his paw" (Wood). Here we have decided efforts at *propitiation* of an offended master or mistress, and after the fashion of man's reconciliations by the shaking of hands, as nearly as the dog can imitate this arrangement. There are cases in which regret or remorse leads to the restoration of stolen goods. A dog that had murdered a duck was caught in the act of burying its dead body—that is, of concealing the evidences of his crime. "So deeply was his conscience pricked that when he found himself arrested by a bush he ran the risk of dying of cold and hunger rather than allow himself to be discovered" (Wood). When a large, magnanimous, powerful dog—for instance, of the Newfoundland breed—has allowed impulse or passion to hurry it into some rash act, such as killing or too severely punishing some puny pug that has been merely forward, impudent, or annoying, it frequently and eloquently expresses its shame, regret, or remorse.

As in man, conscience or conscientiousness sometimes has its strange or striking vagaries, eccentricities, or inconsistencies in other animals. Thus a retriever that would himself touch no food belonging to his master, yet offered no objection to theft of the same food by a cat, nor did he decline to accept a share of *her* plunder (Wood).

Not only do animals feel their own wrong-doing, but they appreciate evil or evil deeds in their young and in their fellows, including other genera and species, and man himself. They show this, for instance (1), by the punishment of offenders, if not of offenses, as well as (2) by the prevention of threatened wrong-doing or the defense of the wronged, or (3) by the resentment or revenge of injury or injustice of any kind. Thus various animals resent and revenge the wrongs committed by *man* not only on themselves or their fellows, but even on brother man; and this sense of wrong or injury inflicted upon others leads sometimes to their *defense of man* against his fellow man. A case happened recently in Ireland of a pet cow that defended its mistress against the ill usage of its master, its mistress's husband; and many instances have been recorded of the dog, elephant, and horse doing similar kindnesses to their human favorites. It ought to be not a little humiliating to man's pride that the so-called "lower" animals have so frequently to act as *mediators* in human quarrels—to defend lordly man against his own species.

In the same sense in which it can be said that the dog and other animals are endowed sometimes with a perception of wrong, it may also be said that they acquire a sense of the *illegality* of certain not only of their own actions, but also of man's. Human tribunals have apparently regarded sheep-stealing dogs as conscious of the illegality of their deeds, as sensible of the nature of their nefarious employment, as aware of the character of their offense or crime, as alive to the chances of detection and of the necessity for secrecy or concealment, for nocturnal operations, for the avoidance of being found associated with any of the evidences of guilt, as feeling that they deserve punishment and that they will receive it on capture or conviction. These tribunals have, in other words, recognized the power the guilty animals have possessed of selecting between the right and the wrong, and of their having chosen the latter with full knowledge of consequences. And in all these respects human judges have so far formed correct conclusions or decisions, though they have erred in forgetting that the criminality in such cases has been the evil fruit of man's education of his animal accomplices. The dogs of the brigand, smuggler, or poacher, like those of the sheep-stealer, display a knowledge of the illegality of the operations in which they are habitually engaged. They take all means of avoiding custom-house officers or gamekeepers, deliberately making use of all kinds of deception; but to all this they are trained by man.

No doubt what is popularly spoken of as a sense of right or wrong, of legality or illegality, in the lower animals may, or will if strictly analyzed, be reduced to a distinction between what is *forbidden* and what is *permitted* by man, who is recognized as a sufficient lawgiver and administrator—what will bring *punishment* on the one hand and *reward* on the other. But this is just the kind of feeling as to right and wrong, legality and illegality, that exists in the savage adult, that is generated at first in the civilized child, that is exhibited (if at all) in the criminal, the lunatic, or the idiot. It can not be truthfully affirmed that *abstract* or refined *ideas* of moral good and evil are common to all ranks of men, or are innate even in civilized man. In our brother man, and with all the help that spoken and written language can give us, there can be no doubt of the difficulty, frequently the utter impossibility, of knowing whether any and what conceptions exist as to right or wrong, good or evil, justice or injustice, honesty or dishonesty. It need, therefore, be no matter of surprise if we can not ascertain or demonstrate the presence or absence of any sort of definite conceptions on such subjects in the dogs, fowls, or other domestic animals that are so constantly under man's observation. Practically, however, as has been seen, as practically as in whole races of man, the dog and other animals give unquestionable evidence that they know what, according to man's law to them, is right and wrong, and they prefer to do the one or the other according to their individuality and the character of their previous moral training.

Monkeys and other animals sometimes show, as much as does the human child, a very decided enjoyment of *forbidden* pleasures, not only knowing that they are, but because of their being, interdicted.

The dog, horse, mule, elephant, and other animals have frequently a distinct sense, feeling, or knowledge of *duty*, trust, or task ; and this not only as regards their own personal obligations, but in so far as duty of various kinds is attachable to other individuals of the same species, or to those of other genera and species, including man himself—when, for instance, such duty of man's has any immediate reference to, or connection with, themselves. In other words, they have clear conceptions of their own duties and of the duties of others, including man, in relation to them.

The discharge of their own duties, which in many instances are *self-imposed*, involves, or is characterized by—

1. An *understanding of the nature of the work* to be executed—of the duty required, for instance, by man.

2. *Conscientiousness* in the discharge of duty, which again implies—

a. Sterling *honesty* and fidelity.

b. Willingness or *zeal.*

c. *Regularity*, including perseverance, patience, and method.

d. *Accuracy*, based on high intelligence.

The working elephant requires that the nature of its work should be explained to it, to as great an extent as possible demonstratively—by illustration. It very quickly and readily comprehends what it is that man wishes and expects it to do, and it very soon learns to execute its task without supervision, bringing to the discharge of its duty so much zeal or heartiness, so much conscientiousness, that it frequently displays an obvious *dread of failure* in, or of inability for, the due fulfillment of its trust, even when the causes of such failure or incompetency, where they exist, scarcely come within, or are altogether beyond, the animal's control. There are such things in the dog, elephant, horse, and other animals as excess of zeal, wrong ideas of duty, mistakes in the mode of discharging it, and *morbid conscientiousness*. Man's cruel taunts not unfrequently lead the too willing horse or elephant to the attempting of tasks for which their strength, or lack thereof, does not qualify them, and death in or from such attempts is the occasional result; while the dog sometimes carries its honesty or fidelity in the defense of a trust to a ridiculous extent, or displays qualities, noble in themselves, under absurd circumstances. The dog's anxiety to learn his duty has been pointed out by the Ettrick Shepherd, who thus writes of his celebrated Sirrah: "As soon as he discovered that it was his duty [to turn sheep], and that it obliged me, I can never forget with what anxiety and eagerness he learned his different evolutions."

Duties that are *voluntarily assumed*, that are frequently of an irksome and even of an unnatural kind, are sometimes discharged in the most admirable way—for instance, by self-constituted *foster-parents* that have adopted orphaned or deserted young, often belonging to other genera and species, and even to natural enemies.

Quite as frequently, perhaps, parental or maternal duties of a natural and important character are *delegated or left* to any other animal possessed of a sufficiently powerful charity or compassion, a sufficiently strong maternal or parental "instinct." The duties of parentage or otherwise may be simply left undischarged without the slightest regard to the results of such neglect; every opportunity may be taken of shirking work that is disagreeable, or a task of whatever nature is executed in a very perfunctory, perhaps merely nominal way. There is, in other words, in some cases just as decided an insensibility to the claims of duty, just as marked a cold indifference to its discharge, as in other cases there are conscientiousness and kindliness. It is only fair, however, to bear in mind that such *apathy*, frequently of an obviously unnatural character, is one of the common results of *mental defect or disorder*, just as it is too frequently in man himself.

The dog frequently makes duty and its discharge paramount to all other considerations. To it are sacrificed even revenge on the one hand, or temptations to the pursuit of game, or to access to food, on the other. Death itself is sometimes preferred to the desertion of a trust or charge (Watson). Many a dog restrains all its natural propensities under a sense of duty and responsibility. When on "duty," intrusted with a message from a master, it very literally places "business before pleasure"; its self-control may even prevent desirable or necessary self-defense.

Whether it be from a sense of justice, of duty, or of conscientiousness, it is a fact that certain working dogs and other animals not only attend faithfully to their own duties, but see that their companions give equal attention to theirs. They *exact duty* or work from, or enforce it in, their colleagues (Watson).

Certain of the lower animals have a very decided sense of *justice and injustice*, of equity or fairness and the reverse. Thus the dog, horse, mule, ass, camel, elephant, and other working animals have a feeling that "the laborer is worthy of his hire"; that they deserve a certain meed of praise, credit, or reward—a certain return in food and drink, in domestic comfort or personal attention—for service rendered. There is a clear recognition of the value of service—a knowledge of personal deserts. Hence they so frequently exhibit a sore sense of ill-requital of hard labor or of self-sacrifice. Punishment which they know to be undeserved they resent—sometimes dangerously to man—and in doing so they discriminate and estimate man's injustice.

The bread-buying dog does very much the same thing—detects and protests against man's unfair dealing when, offering its penny for a roll, a baker tries, waggishly or otherwise, to cheat it by giving it something of inferior value or refusing it a *quid pro quo* at all.

There must further exist in certain animals some perception of the distinction between spoken as well as acted *truth and falsehood*, fact and fiction; for we are told, for instance, that the parrot sometimes not only detects but denounces with the utmost indignation man's verbal falsehoods ("Animal World"). On the other hand, one of the occasionally base or bad purposes to which the same bird applies its wonderful gift of speech is *mendacity:* so that it is capable at once of "telling lies" itself and of detecting and reprimanding falsehood in man.

A certain sentiment of *decency*, modesty, or propriety occurs in various social animals, illustrated as it is by—

1. Their sexual bashfulness and chastity.
2. Their care of the dead, including the—
3. Use of dying-places and cemeteries.
4. Their employment of latrines or their equivalents.

It has to be remarked that the moral virtues are illustrated mainly by or in those animals that have directly or indirectly received their *moral training* from man—such animals as the dog, elephant, and horse. As a general rule—to which there are exceptions both in man and other animals—the human child and the young animal can equally be educated both to *distinguish and do the right*. In the formation of their characters *moral virtue* may be made to dominate over moral vice though it is probably impossible in either case to extinguish the latter. Moral perfectibility may be aimed at, though it can not be attained; but the degree of moral excellence attainable is such in other animals, as in the child, that it should stimulate man to put forth all efforts in the moral training of both.

MIDDLE-AGE SPIRITUALISM.

THE doctrine of human intercourse with invisible beings or spirits is as old as superstition, and has its fashions, or, rather, it takes on different phases according to the degrees of ignorance and stupidity that characterize society. It was one thing in Greece and Rome, and a very different thing in the middle ages. In the former there was a mythologic machinery of gods and goddesses, who meddled actively with terrestrial affairs, both in peace and war. This was the dignified sort of spiritualism that is embalmed in classical literature, and which continues to form the corner-stone of a "college education."

The spiritualism of the middle ages took a very different shape. It was more intense, realistic, practical, and vulgar—more earnest, and, we are bound to say, more honest. The spirits were brought to bear, so to speak, more intimately upon common life. The line between good and bad spirits was more sharply drawn; they were angels or demons, ever working mischief or benefit to mankind. The art of evoking spirits became a kind of craft under the names of divination, magic, sorcery, enchantment, necromancy, and witchcraft. In the modern survival of these old practices of evoking spirits we get very different results. The ghosts believed to be called up by manipulation are of a more harmless character; and the object seems to be rather to get the spirits out, than to get anything out of them. They are summoned more as a matter of curiosity, and for the solemn amusement of credulous and vacant minds.

Science has worked a great change in relation to this subject. It has drawn the teeth of mediæval ghostology. Though it has not extirpated the belief in spirits, it has greatly transformed and subdued it, so that it is no longer the scourge and curse of society that it was in the pre-scientific ages. We are apt to forget what we owe to science in this respect, and the horrors that modern society has escaped by getting rid of the grosser and more malignant forms of belief in ghostly supersensuous and diabolic agency. But fully to appreciate our advantages it is necessary, once in a while, to turn back and contemplate the condition of things in the ages of ignorance, when men were given over to the terrors of vicious and cruel superstitions. An admirable book has been lately published, which presents a vivid picture of the general state of mind and society a few centuries ago in Western Europe, resulting from the current belief in supernatural agencies, and we propose to cull a few statements from its pages in illustration of the subject.*

* The Magic of the Middle Ages. By Viktor Rydberg. Translated from the Swedish by August Hjalmar Edgren. New York: Henry Holt & Co.

The author first finds the theological root of his subject. During the middle ages it was held that all power or force was spiritual, that it came from a spiritual source—from God—and was communicated to the earth by spiritual agents or angels. No inevitable causation was admitted. The laws of nature were the precepts in accordance with which the angels executed the will of God. Sometimes he suspended their agency, acting everywhere himself, or he delegated unusual power to them, when their operations were known as miracles. Hence a knowledge of nature was at this time chiefly a knowledge of the angels. Lucifer, the highest of these angels, rebelled against God. The contest ended with the overthrow of the rebel and his followers; but God, calm in the consciousness of his omnipotence, determined that Lucifer, now changed by his rebellion into a spirit wholly evil, should enjoy liberty of action within certain limits. The activity of the fallen spirit consists henceforth in incessant warfare against God. Man is tempted and falls. The earth is divided into two antagonistic kingdoms, those of good and evil. Over one reigns God and his angels of light, over the other the devil and his minions. Such was the dualistic conception of the middle ages, and to it may be traced the magic of the Church, the astrology, alchemy, and sorcery of the learned, as well as the diabolic forms of witchcraft believed in by the common people.

The Church, exercising its watch-care for man, surrounded him from the cradle to the grave by the safeguards of magic. Thus, soon after the birth of the child the priest must be ready to sprinkle it with holy water, which has been purified from the pollution of demons by prayer and conjuration; and so strong was the impression that the child, begotten in sin and by nature Lucifer's property, would be doomed to the torments of hell without the grace of baptism, that certain conscientious servants of the Church attempted to devise some means by which the saving water might be brought in contact with the child before it saw the light.

Holy water, when drunk by the sick and infirm, healed and strengthened; if sprinkled upon the field it promoted fertility, and given to domestic animals it afforded them protection against witchcraft.

Says Thomas Aquinas: "It is a dogma of faith that the demons can produce wind, storms, and rain of fire from heaven. The atmosphere is a battle-field between angels and devils. The latter work the constant injury of man, the former his melioration; and the consequence is that changeableness of weather which threatens to frustrate the hopes of husbandry. And, when Lucifer is able to bestow even upon man—sorcerers and wizards—the power to destroy the fields, the vineyards, and dwellings of man by rain, hail, and lightning, is it to be wondered at if the Church, which is man's protection against the devil, and whose especial calling it is to fight him, should in this sphere also be his counterpoise, and should seek, from the treasury of its divine power, means adequate to frustrate his atmospheric mischiefs? To these means belong the church-bells, provided they have been duly consecrated and baptized. The aspiring steeples, around which cluster the low dwellings of men, are to be likened, when the bells in them are ringing, to the hen spreading its protecting wings over its chickens; for the tones of the consecrated metal repel the demons and avert storm and lightning."

During protracted drought it was the custom for the priests to make intercession and inaugurate rain-processions, and it is narrated that, in the year 1240, in Lüttich a large rain-procession failed, three times, to produce any effect, "because, in the supplication of all saints, God's mother had been forgotten." A new procession was formed, due respect was shown her Majesty, and the rain immediately came down with such violence that the devout procession was dispersed.

If the fields were visited by destructive insects, the Church had remedies against them also. It commanded them in the name of God to depart; and, if they did not obey, regular processes were instituted against them, which ended in their excommunication by the Church. In the year 1474 the May-bug committed great depredations in the neighborhood of Berne. The authorities of the city sought relief against the scourge from the Bishop of Lausanne, who issued a letter of excommunication, which was solemnly read by a priest in the churchyard of Berne. The letter began thus: "Thou irrational, imperfect creature, thou May-bug, thou whose kind was never inclosed in Noah's ark; in the name of my gracious lord the Bishop of Lausanne, by the power of the glorified Trinity through the merits of Jesus Christ, and by the obedience you owe the Holy Church, I command you, May-bugs, all in common and each one in particular, to depart from all places where nourishment for man and cattle germinates and grows." The letter ends with a summons to the insects to present themselves at Wivelsburg on the sixth day thereafter, at one o'clock, if they do not disappear before that time, and assume the responsibility before the court of the gracious lord of Lausanne! Arrangements were made beforehand for a legal trial; the accused, of course, was to have a lawyer, and the Bishop devised the plan of summoning from hell the spirit of an infamous one named Perrodet, who had died a few years before. But, in spite of many summonses, neither Perrodet nor the May-bugs deigned to appear, and finally the episcopal tribunal gave its verdict of excommunication in the name of the Holy Trinity—"to you accursed vermin, that are called May-bugs, and which can not even be counted among the animals." The Government ordered the authorities of the afflicted district to report concerning the effects of the measure; but a chronicle of the time reports that "no effect was observed, because of our sins."

The most scrupulous attention to legal forms was given to the frequently recurring processes against May-bugs, grasshoppers, worms, and other noxious vermin, for any neglect of these forms was supposed to deprive a judgment of its magical power. The question whether they were subject to a spiritual or legal tribunal was much agitated, but without being definitely settled. A civil prosecution of the field-rats in the Tyrol, 1519–'20, proves that sometimes such suits were decided by secular tribunals.

The peasant, Simon Fliss, made complaint to the judge, William of Hasslingen, that the field-rats were committing great depredations in his parish. The court then appointed Hans Grinebner advocate for the accused, and the plaintiff chose as his advocate Schwarz Minig. Numerous witnesses established the fact that the rats had committed great destruction, and the decision was rendered against them in the following terms: "After accusation and defense, after statement and contradiction, and after due consideration of all that pertains to justice, it is by this sentence determined that those noxious animals which are called field-rats must, within two weeks after the promulgation of this judgment, depart and for ever remain far aloof from the fields and the meadows of Stilf. But if one or several of the animals are pregnant, or unable on account of their youth to follow, then shall they enjoy, during further two weeks, safety and protection from everybody, and after these two weeks depart."

Nothing was too absurd, nothing too superstitious, for the credulity of this period. The consecrated machinery was so various and complete that, if one explanation did not serve the purpose of the Church, another could usually be found. One question, however, did not readily find an answer, namely: How are the divine miracles to be distinguished from the infernal ones? Attempts of the acutest scholastics failed to establish a rule of definite separation; for the two kinds of miracles were revealed under identical forms, and Satan could transform himself into an angel of light. The grossest doctrines received the sanction of the Church, and thus was laid the foundation of that labyrinth of superstitions among the people in the darkness of which humanity groped for a thousand years. If the miracles worked by the apostles of the Church had their source in divine agencies, then those performed by its opponents must have been instigated by the devil. The white magic stood opposed to the black, and the idea of a conscious league between the devil and man became a well-established dogma.

In the fifteenth century there came a terrible crisis. This was preceded by the trial of the Templars and by several local witch-processes with subsequent executions, until finally, December 5, 1484, the bull of Pope Innocent VIII. appeared. This, with its companion, a book called "The Witch-hammer," brought the evil to a climax. Some idea of this bull may be gathered from the following extract. The Pope begins by asserting that, as the guardian of souls, he must exercise care in promoting the growth of the Catholic faith and driving heresy far from the faithful. "But," he continues, "it is not without profound grief that I have learned recently that persons of both sexes, forgetting their own eternal welfare and erring from the Catholic faith, mix with devils, with *incubi* and *succubi*, and injure by witch-songs, conjurations, and other shameful practices, revelries, and crimes, the unborn children of women, the young of animals, the harvests of the fields, the grapes of the vineyards, and the fruit of the trees; that they also destroy, suffocate, and annihilate men, women, sheep and cattle, vineyards, orchards, meadows, and the like; visit men, women, cattle and other animals with internal and external pains and sickness; prevent men from procreation and women from conception, and render them entirely unfit for their mutual duties, and cause them to recant, besides, with sacrilegious lips, the very faith which they have received in baptism." The Pope therefore appoints the professors of theology, Henry Institor and Jacob Springer, to be prime inquisitors, with absolute power over all districts which are contaminated with those diseases. Finally, he proclaims that no appeal from the tribunals of the inquisitors to other courts, not even to the Pope himself, will be allowed. The inquisitors and their assistants are invested with unlimited power over life and death, and are exhorted to fulfill their commission with zeal and severity. The bull contains no directions as to how the judges should proceed in the trial of witches, but "The Witch-hammer," bearing the sanction of the Pope, is most explicit upon the subject. This book became juridical authority, and was followed even in Protestant countries until early in the eighteenth century. It begins by attempting to show that its theories are entirely founded upon the Scriptures. The history of Job, the temptation of Jesus in the desert, and the many demoniacs mentioned in the New Testament, are adduced to prove that Satan can dwell in man and use the human body as his implement. Moreover, Moses ordained that witches should be put to death, a command which would be entirely superfluous, if witches had not existed. "The Witch-hammer" then broaches the question why it is that women are especially addicted to sorcery, and devotes thirty-three pages to the proof thereof. The following is an example of its argument: The holy fathers have often said that there are three things which have no moderation in good or evil—the *tongue*, a *priest*, and a *woman*. Concerning woman this is evident. All ages have made complaints against her. The wise Solomon, who was himself tempted to idolatry by woman, has often in his writings given the feminine sex a sad but true testimonial; and the holy Chrysostom says: "What is woman but an enemy of friendship, an unavoidable punishment, a necessary evil, a natural temptation, a desirable affliction, a constantly flowing source of tears, a wicked work of nature covered with a shining varnish?" Already had the first woman entered into a sort of compact with the devil; should not, then, her daughters do it also? The very word *femina* (woman) means *one wanting in* *faith;* for *fe* means "faith," and *minus* "less." Since she was formed of a crooked rib, her entire spiritual nature has been distorted and inclined more toward sin than virtue. If we here compare the words of Seneca, "Woman either loves or hates; there is no third possibility," it is easy to see that when she does not love God she must resort to the opposite extreme and hate him. It is thus clear why women especially are addicted to the practice of sorcery.

The crime of the witches exceeds all others. They are worse than the devil, for he has fallen once for all, and Christ has not suffered for him. The devil sins, therefore, only against the Creator, but the witch both against the Creator and Redeemer. The theology of the case is perfectly clear.

These and similar questions the first part of "The Witch-hammer" attempts to settle. The second part describes the various kinds and effects of witchcraft. It claims that they produce hail, thunder, and storms; they fly through the air from one place to another; they can make themselves insensible on the rack; they often subdue the judge's mind by charms and *confuse him through compassion;* they change themselves and others into cats and were-wolves; nay, they are able to enchant and kill men and beasts by their very looks. Their strongest passion is to eat the flesh of children; still they eat only unchristened children: if at any time a baptized child is taken by them, it happens by special divine concession.

Their compact with the devil may be of a private nature, or a solemn one entered into with due formalities. When the latter, it is concluded in the following manner: The witches assemble upon a day set apart by the devil. He appears in the assembly, exhorts them to faithfulness, and promises them glory, happiness, and long life. The older witches then introduce the novices, who are put to the test and take the oath of allegiance. The devil then instructs them how to prepare from the limbs of new-born babes witch-potions and witch-salves, and presents them with a powder, instructing them how to use it to the injury of men and beasts.

The witch accomplishes her voyages in the air by smearing a vessel, a broom, and a rake, a broomstick and a piece of linen, with the witch-salve; then rising she moves forth through the air, visible or invisible. "The Witch-hammer" reminds those who doubt these air-voyages that the devil carried Jesus up through the air to the pinnacle of the temple (Matthew iv. 5).

The third part of this remarkable book gives the criminal law of the witch-courts, with instructions how "sorcerers, witches, and heretics, are to be tried before spiritual as well as civil tribunals." "The Witch-hammer" states "that the trial may commence without any previous accusation." When an inquisitor comes to a place he must exhort everybody by means of proclamations nailed to the doors of churches and town-halls, and by threats of excommunication and punishment, to give information of all persons suspected of witchcraft.

Two or three witnesses are sufficient to prove guilt. In case so many do not present themselves, the judge may find and summon them and force them to tell the truth under oath. The qualifications necessary for witnesses to possess will appear from the statement that the excommunicate, accomplices, outlawed, runaway and dissolute women, are irreproachable witnesses in cases where the faith is involved. A witch is allowed to testify against a witch, wife against husband, husband against wife, children against parents, and so on; but, if the testimonies of accomplices or relatives are to the advantage of the accused, then they are of no validity, *for blood is of course thicker than water*, and one raven does not willingly pick out the eyes of another.

An accused may have an advocate, but "The Witch-hammer" adds: "If the counselor defends his suspected client too warmly, it is right and reasonable that he should be considered as far more criminal than the sorcerer or the witch herself; that is to say, as the protector of witches and heretics he is more dangerous than the sorcerer. He should be looked upon with suspicion in the same degree as he makes a zealous defense." "The Witch-hammer" then informs the judge of five "honest and apostolic tricks" by means of which the accused and their lawyer may be confused. The quality of the questions put to the accused may be appreciated from the following examples: "Do you know that people hold you to be a witch? Why have you been observed upon the precincts of N. N.? Why have you touched N. N.'s child (or cow)? How did it happen that the child (or the cow) soon after fell sick? What was your business outside of your house when the storm broke forth? How can you explain that your cow yields three times as much milk as the cows of others?"

Before the trial of a person accused of sorcery, he was put on the rack in order that his mind might be inclined to confession. The "worst witches" were those who allowed themselves to be torn asunder, limb by limb, and their endurance is explained by the supposition that "the devil hardens them against their tortures." If confession was not wrung from the witch the first day, the torture was to be *continued* the second and third day. The civil law forbade the *repeating* of the torture. Hence the following formula used by the judge: "We ordain that the torture shall be *continued* (not *repeated*) to-morrow." The second day the instruments of torture were exhibited, and the accused was adjured, by all holy names, if innocent, to pour forth immediately abundant tears; but, if guilty, no tears at all.

If tears should flow, the judge was directed to see that it be not saliva, or other fluid; and the witch was led into the court-room backward, that the judge might see her before she saw him. Otherwise he might be moved to criminal compassion by her enchantment.

It was still further provided that the limbs of the accused should be examined to see if they bore devil's marks. The absence of such marks, however, did not prove innocence.

With the fullest directions as to the ways and means to be adopted for the ensnaring of witches this dreadful book concludes. The effect of the fires kindled by the bull of Pope Innocent was felt far into the eighteenth century. The victims were counted by millions. Says an author of the seventeenth century, "When they had commenced in one place to burn witches, more were found in proportion as they were burned"; and it is also stated that in certain communities in Germany and France *all* the women were sent to the stake; and in many instances princes and potentates were forced, from fear of seeing their subjects exterminated, to stay by *authoritative command* the madness of the inquisitors.

No age was exempt. Children were brought to the stake with their mothers. A gloomy presentiment pervaded the community when the proclamation on the church-doors announced the arrival of the inquisitor. Work in the shops and fields ceased; and the person who had an open enemy, or suspected secret envy, knew beforehand that he was lost. And the arch-fiend was the agent and instigator of all this madness. "He was in the castle of the knight, the palaces of the mighty, the libraries of the learned, on every page of the Bible, in the churches, in the halls of justice, in the lawyer's chambers, in the laboratories of physicians and naturalists, in cottages, farm-yards, stalls, everywhere."

The popular literature of this period consisted of legends of saints and stories about the devil. There were imps, giants, trolls, forest spirits, elves, and hobgoblins on the earth; nicks, river-sprites in the water, fiends in the air, and salamanders in the fire. There were monsters such as dragons, griffins, were-wolves, witch-kind, Thor's-swine, and supernatural beings derived from the human world, but of dimmer outlines than the preceding.

Among these last was the mandragora, which was supposed to reveal to its possessor hidden things and future events, and to secure the friendship of all men. The root of the mandragora, or mandrake, often divides into two parts, and thus presents a rude resemblance to a human figure. It was believed that this plant could not be found except below the gallows where a pure youth had been hanged. When torn from the soil it was said to sigh, shriek, and moan so piteously that it caused whoever heard it to die. To find this plant it must be sought before sunrise Friday morning. The person seeking it should carefully fill his ears with cotton, wax, or pitch, and take with him a black dog, without a single white hair. The sign of the cross was to be made three times over the mandragora, then the soil was to be carefully removed, so that it was attached only by its fine rootlets. It was then tied by a string to the tail of a dog, who was attracted forward by a piece of bread. The dog pulled the plant from the earth, but fell dead, struck by the shriek of the mandragora. The plant was then taken home, washed in red wine, and wrapped in red-and-white silk, laid in a shrine, washed on successive Fridays, and dressed in a white frock. If the mandragora is bought it remains with the person who thus secures it, regardless of where it is thrown, until sold again. If kept until death, the person must depart to hell with it.

In the demoniacal fauna of the middle ages were-wolves played an important part. They were supposed to be men who changed themselves for a time into wolves, and roved about hunting for children. Augustine, one of the most prominent of the fathers and authors of his time, taught that it was the devil who wrapped a wolf's hide around a witch. Melanchthon also believed in this doctrine, and the Emperor Sigismund had the question investigated "scientifically" in the presence of theologians, and they came to the general agreement that the were-wolf is "a positive and constant fact"; for, the existence of the devil being accepted, there is no reason to deny that of the were-wolf, supported as it is by the authority of the fathers of the Church and by general experience.

Another ghastly superstition of those times was that of belief in vampires. These were disembodied souls, which had reclothed themselves in their buried bodies. In this garb they stole at night into houses and sucked from the nipples of the sleeping their blood. The person thus bereft of his vital fluid was in turn changed into a vampire. The corpse of a person suspected of vampirism, if dug up, was found well preserved, and an abundance of fresh blood would flow from its mouth on pressing the stomach. To this horrible belief is ascribed a kind of psychical pestilence, which spread terror in the Austrian provinces even down into the eighteenth century.

We have here given only a few examples of middle-age spiritualism, and must refer the curious reader to the instructive pages of Professor Rydberg's book for the fuller presentation of this painful subject. The statements we have given may seem in the last degree ludicrous and incredible, but they imply tragic realities and an unspeakable wretchedness in the mental states where such notions could be harbored. The age that built the cathedrals of Europe was one of fanatical religious earnestness, and from this we may infer the terrible sincerity of the horrors of insane superstition by which the minds of people were darkened and poisoned.

HISTORY AND METHODS OF PALEONTOLOGICAL DISCOVERY.*

By Professor O. C. MARSH.

II.

WHILE the Paris Basin was yielding such important results for paleontology, its geological structure was being worked out with great care. The results appeared in a volume by Cuvier and Alexandre Brongniart, chiefly the work of the latter, published in 1808.† This was the first systematic investigation of Tertiary strata. Three years later, the work was issued in a more extended form. The separate formations were here carefully distinguished by their fossils, the true importance of which for this purpose being distinctly recognized. This advance was not accepted without some opposition, and it is an interesting fact that Jameson, who claimed for Werner the theory here put in practice, rejected its application, and wrote as follows: "To Cuvier and Brongniart we are indebted for much valuable information in their description of the country around Paris, but we must protest against the use they have made of fossil organic remains in their geognostical descriptions and investigations." ‡

William Smith (1769–1839), "the father of English geology," had previously published a "Tabular View of the British Strata." He appears to have arrived independently at essentially the same view as Werner in regard to the relative position of stratified rocks. He had determined that the order of succession was constant, and that the different formations might be identified at distant points by the fossils they contained. In his later works, "Strata identified by Organized Fossils," published in 1816–'20, and "Stratigraphical System of Organized Fossils," 1817, he gave to the world results of many years of careful investigations on the Secondary formations of England. In the latter work, he speaks of the success of his method in determining strata by their fossils, as follows: "My original method of tracing the strata by the organized fossils imbedded therein is thus reduced to a science not difficult to learn. Ever since the first written account of this discovery was circulated in 1799, it has been closely investigated by my scientific acquaintances in the vicinity of Bath, some of whom search the quarries of different strata in that district with as much certainty of finding the characteristic fossils of the respective rocks as if they were on the shelves of their cabinets."

The systematic study of fossils now attracted attention in England also, and was prosecuted with considerable zeal, although with less

* President's address delivered before the American Association for the Advancement of Science, at Saratoga, New York, August 28, 1879.

† "Essai sur la Géographie Mineralogique des Environs de Paris," 4to, 1808.

‡ Translation of Cuvier's discourse, Note K. (B.), p. 103, 1817.

important results than in France. An extensive work on this subject, by James Parkinson, entitled "Organic Remains of a Former World," was begun in 1804, and completed in three volumes in 1811. A second edition appeared in 1833. This work was far in advance of previous publications in England, and, being well illustrated, did much to make the collection and study of fossils popular. The belief in the geological effects of the deluge had not yet lost its power, although restricted now to the later deposits; for Parkinson, in his later edition, wrote as follows: "Why the earth was at first so constituted that the deluge should be rendered necessary—why the earth could not have been at first stored with all those substances and endued with all those properties which seemed to have proceeded from the deluge—why so many beings were created, as it appears, for the purpose of being destroyed—are questions which I presume not to answer."

William Buckland (1784–1856) published in 1823 his celebrated "Reliquiæ Diluvianæ," in which he gave the results of his own observations in regard to the animal remains found in the caves, fissures, and alluvial gravels of England. The facts presented are of great value, and the work was long a model for similar researches. Buckland's conclusions were, that none of the human remains discovered in the caves were as old as the extinct mammals found with them, and that the deluge was universal. In speaking of fossil bones found in the Himalaya Mountains, he says: "The occurrence of these bones at such an enormous elevation in the region of eternal snow, and consequently in a spot now unfrequented by such animals as the horse and deer, can, I think, be explained only by supposing them to be of antediluvian origin, and that the carcasses of the animals were drifted to their present place, and lodged in sand, by the diluvial waters."

The foundation of the "Geological Society of London," in 1807, marks an important point in the history of paleontology. To carefully collect materials for future generalizations was the object in view, and this organization gradually became the center in Great Britain for those interested in geological science. The society was incorporated in 1826, and has since been the leading organization in Europe for the advancement of the sciences within its field. The Geological Society of France, established at Paris in 1832, and the German Geological Society, founded at Berlin in 1848, have likewise contributed largely to geological investigations in these countries, and to some extent in other parts of the world. In the publications of these three societies the student of paleontology will find a mine of valuable materials for his work.

The systematic study of fossil plants may be said to date from the publication of Adolphe Brongniart's "Prodrome," in 1828.* This was very soon followed by his larger work, "Histoire des Végétaux Fos-

* "Prodrome d'une Histoire des Végétaux Fossiles," 8vo, Paris, 1828.

siles," issued in 1828–'48. Brongniart pursued the same method as Cuvier and Lamarck, viz., the comparison of fossils with living forms, and his results were of great importance. In his "Tableau des Genres Végétaux Fossiles," etc., published in Paris in 1849, he gives the classification and distribution of the genera of fossil plants, and traces out the historical progression of vegetable life on the globe, as he had done to a great extent in his previous works. He shows that the cryptogamic forms prevailed in the Primary formations, the conifers and cycads in the Secondary, and the higher forms in the Tertiary, while four fifths of living plants are exogens.

In England, Lindley and Hutton published, in 1831–'37, a valuable work in three volumes, entitled "Fossil Flora of Great Britain." This work was illustrated by many accurate plates, in which the plants of the coal formation were especially represented. Henry Witham also published two works in 1831 and 1833, in which he treated especially of the internal structure of fossil plants. "Antediluvian Phytology," by Artis, was published in London in 1838. Bowerbank's "History of the Fossil Fruits and Seeds of the London Clay" appeared in 1843. Hooker's memoir "On the Vegetation of the Carboniferous Period as compared with that of the Present Day," published in 1848, was an important contribution to the science. Bunbury, Williamson, and others, also published various papers on fossil plants. This branch of paleontology, however, attracted much less attention in England than on the Continent.

In Germany, the study of fossil plants dates back to the beginning of the century. Von Schlotheim, a pupil of Werner, published in 1804 an illustrated volume on this subject. A more important work was that of Count Sternberg, issued in 1820–'38, and illustrated with excellent plates. Cotta, in 1832, published a book with the title "Die Dendrolithen," in which he gave the results of his investigations on the inner structure of fossil plants. Von Gutbier, in 1835, and Germar, in 1844–'53, described and figured the plants of two important localities in Germany. Corda's "Beiträge zur Flora der Vorwelt," issued at Prague, in 1845, was essentially a continuation of the work of Sternberg. Unger's "Chloris Protogæa," 1841–'45, "Genera et Species Plantarum Fossilium," 1850, and his larger work, published in 1852, are all standard authorities. It the latter, the theory of descent is applied to the vegetable world. Schimper and Mougeot's "Monograph on the Fossil Plants of the Vosges," 1845, was well illustrated, and contained noteworthy results.

Göppert in 1836 published a valuable memoir entitled "Systema Filicum Fossilium," in which he made known the results of his study of fossil ferns. In the same year, this botanist began a series of experiments in which he attempted to imitate the process of fossilization, as found in nature. He steeped various animal and vegetable substances in waters holding, some calcareous, others siliceous, and others metallic matter in solution. After a slow saturation, the substances were dried, and exposed to heat until the organic matters were burned. In this way Göppert successfully imitated various processes of petrifaction, and explained many things in regard to fossils that had previously been in question. His discovery of the remains of plants throughout the interior of coal did much to clear up the doubts about the formation of that substance. In 1841 Göppert published an important work in which he compared the genera of fossil plants with those now living. In 1852 another extensive work by this author appeared, entitled "Fossile Flora des Uebergangs-Gebirges."

Andræ, Braun, Dunker, Ettingshausen, Geinitz, and Goldenberg, all made notable contributions to fossil botany in Germany during the period we are now considering.

The systematic study of invertebrate fossils, so admirably begun by Lamarck, was continued actively in France. The Tertiary shells of the Seine Valley were further investigated by Defrance, and especially by Deshayes, whose great work on this subject was begun in 1824.* Des Moulins's essay on "Sphérulites" in 1826, Blainville's memoir on "Belemnites" in 1827, Férussac's various memoirs on land and fresh-water fossil shells, were valuable additions to the subject. A later work of great importance was D'Orbigny's "Paléontologie Française," 1840–'44, which described the mollusca and radiates in detail, according to formations. The other publications of this author are both numerous and valuable. Brongniart and Desmarest's "Histoire naturelle des Crustacés Fossiles," published in 1822, is a pioneer work on this subject. Michelin's memoir on the fossil corals of France, 1841–'46, was another important contribution to paleontology. Agassiz's works on fossil Echinoderms and Mollusks are valuable contributions to the science. The works of D'Archiac, Coquand, Cotteau, Desor, Edwards, Haime, and De Verneuil, are likewise of permanent value.

In Italy, Bellardi, Merian, Michellotti, Phillipi, Zigno, and others, contributed important results to paleontology.

In Belgium, Bosquet, Nyst, Koninck, Ryckholt, Van Beneden, and others have all aided materially in the progress of the science.

In England, also, invertebrate fossils were studied with care, and continued progress was made. Sowerby's "Mineral Conchology of Great Britain," in six volumes, a systematic work of great value, was published in 1812–'30, and soon after was translated into French and German. Its figures of fossil shells are excellent, and it is still a standard work. Miller's "Natural History of the Crinoidea," published at Bristol, in 1821, and Austin's later monograph, are valuable for reference. Brown's "Fossil Conchology of Britain and Ireland" appeared in 1839, and Brodie's "History of the Fossil Insects of England" in 1845. Phillips's illustration of the geology of Yorkshire, 1829–'36, and

* "Description des Coquilles Fossiles des Environs de Paris," 3 vols., Paris. 1824–'37.

his work on the Palæozoic fossils of Cornwall, Devonshire, and West Somerset, 1843, contained a great deal of original matter in regard to fossil remains. Morris's "Catalogue of British Fossils," issued in 1843, and the later edition in 1854, is most useful to the working paleontologist. The memoirs of Davidson on the Brachiopoda, Edwards, Forbes, Morris, Lycett, Sharpe, and Wood on other Mollusca, Wright on the Echinoderms, Salter on Crustacea, Busk on Polyzoa, Jones on the Entomostraca, and Duncan and Lonsdale on Corals, are of especial value. King's volume on Permian fossils, Mantell's various memoirs, Dixon's work on the fossils of Sussex, 1850, and McCoy's works on Palæozoic fossils, all deserve honorable mention. Sedgwick, Murchison, and Lyell, although their greatest services were in systematic geology, each contributed important results to the kindred science of paleontology during the period we are reviewing.

In Germany, Schlotheim's treatise, " Die Petrifactenkunde," published at Gotha in 1820, did much to promote a general interest in fossils. By far the most important work issued on this subject was the " Petrifacta Germanica," by Goldfuss, in three folio volumes, 1826–1844, which has lost little of its value. Bronn's "Geschichte der Natur," 1841–'46, was a work of great labor, and one of the most useful in the literature of this period. The author gave a list of all the known fossil species, with full references, and also their distribution through the various formations. This gave exact data on which to base generalizations, hitherto of comparatively little value.

Among other early works of interest in this department may be mentioned Dalman's memoir on " Trilobites," 1828, and Burmeister's on the same subject, 1843. Giebel's well-known " Fauna der Vorwelt," 1847–'56, gave lists of all the fossils described up to that time, and hence is a very useful work. The " Lethæa Geognostica," by Bronn, 1834–'38, and the second edition by Bronn and Roemer, 1846–'56, is a comprehensive general treatise on paleontology, and the most valuable work of the kind yet published.

The researches of Ehrenberg, in regard to the lowest forms of animals and plants, threw much light on various points in paleontology, and showed the origin of extensive deposits, the nature of which had before been in doubt. Von Buch, Barrande, Beyrich, Berendt, Dunker, Geinitz, Heer, Hörnes, Klipstein, Von Münster, Reuss, Roemer, Sandberger, Suess, Von Hagenow, Von Hauer, Zeiten, and many others, all aided in the advancement of this branch of science. Angelin, Hisinger, and Nilsson, in Scandinavia; Abich, de Waldheim, Eichwald, Keyserling, Kutorga, Nordmann, Pander, Rouillier, and Volborth, in Russia; and Pusch in Poland, published important results on fossil invertebrates.

The impetus given by Cuvier to the study of vertebrate fossils extended over Europe, and great efforts were made to continue discoveries in the direction he had so admirably pointed out.

Louis Agassiz (1807–1873), a pupil of Cuvier, and long an honored member of this association, attained eminence in the study of ancient as well as of recent life. His great work on Fossil Fishes* deserves to rank next to Cuvier's "Ossemens Fossiles." The latter contained mainly fossil mammals and reptiles, while the fishes were left without an historian till Agassiz began his investigations. His studies had admirably fitted him for the task, and his industry brought together a vast array of facts bearing on the subject. The value of this grand work consists not only in its faithful descriptions and plates, but also in the more profound results it contained. Agassiz first showed that there is a correspondence between the succession of fishes in the rocks and their embryonal development. This is now thought to be one of the strongest points in favor of evolution, although its discoverer interpreted the facts as bearing the other way.

Pander's memoirs on the fossil fishes of Russia form a worthy supplement to Agassiz's classic work. Brandt's publications are likewise of great value; and those of Lund, in Sweden, have an especial interest to Americans, in consequence of his researches in the caves of Brazil.

Croizet and Jobert's "Recherches sur les Ossemens Fossiles du Département du Puy-de-Dôme," published in 1828, contained valuable results in regard to fossil mammals. Geoffroy Saint-Hilaire's researches on fossil reptiles, published in 1831, were an important advance. De Serres and De Christol's explorations in the caverns in the south of France, published between 1829 and 1839, were of much value. Schmerling's researches in the caverns of Belgium, published in 1833–'36, were especially important on account of the discovery of human remains mingled with those of extinct animals. Deslongchamp's memoirs on fossil reptiles, 1835, are still of great interest. Pictet's general treatise on paleontology was a valuable addition to the literature, and has done much to encourage the study of fossils.† De Blainville, in his grand work, "Ostéographie," issued in 1839–'56, brought together the remains of living and extinct vertebrates, forming a series of the greatest value for study. Aymard and Pomel's contributions to vertebrate paleontology are both of value. Gervais and Lartet added much to our knowledge of the subject, and Bravard and Hébert's memoirs are well known.

The brilliant discoveries of Cuvier in the Paris Basin excited great interest in England, and, when it was found that the same Tertiary strata existed in the south of England, careful search was made for vertebrate fossils. Remains of some of the same genera described by Cuvier were soon discovered, and other extinct animals new to science were found in various parts of the kingdom. König, to whom we owe

* "Recherches sur les Poissons Fossiles," 1833–'45.

† "Traité Élémentaire de Paléontologie," etc., Geneva. 4 vols. 1844–'46, second edition, Paris, 1853–'55.

the name *Ichthyosaurus*, and Conybeare, who gave the generic designation *Plesiosaurus*, and also *Mosasaurus*, were among the earliest writers in England on fossil reptiles. The discovery of these three extinct types, and the discussion as to their nature form a most interesting chapter in the annals of paleontology. The discovery of the *Iguanodon*, by Mantell, and the *Megalosaurus*, by Buckland, excited still higher interest. These great reptiles differed much more widely from living forms than the mammals described by Cuvier, and the period in which they lived soon became known as the "age of Reptiles." The subsequent researches of these authors added largely to the existing knowledge of various extinct forms, and their writings did much to arouse public interest in the subject.

Richard Owen, a pupil of Cuvier, followed, and brought to bear upon the subject an extensive knowledge of comparative anatomy, and a wide acquaintance with existing forms. His contributions have enriched almost every department of paleontology, and of extinct vertebrates especially, he has been, since Cuvier, the chief historian. The fossil reptiles of England he has systematically described, as well as those of South Africa. The extinct Struthious birds of New Zealand he has made known to science, and accurately described in extended memoirs. His researches on the fossil mammals of Great Britain, the extinct Edentates of South America, and the ancient Marsupials of Australia, each forms an important chapter in the history of our science.

The personal researches of Falconer and Cautley in the Siwalik Hills of India brought to light a marvelous vertebrate fauna of Pliocene age. The remains thus secured were made known in their great work, "Fauna Antiqua Sivalensis," published at London in 1845. The important contributions of Egerton to our knowledge of fossil fishes, and Jardine's well-known work, "Ichnology of Annandale," also belong to this period.

The study of vertebrate fossils in Germany was prosecuted with much success during the present period. Blumenbach, the ethnologist, in several publications between 1803 and 1814, recorded valuable observations on this subject. In 1812 Sömmering gave an excellent figure of a pterodactyl, which he named and described. Goldfuss's researches on the fossil vertebrates from the caves of Germany, published in 1820–'23, made known the more important facts of that interesting fauna. His later publications on extinct amphibians and reptiles were also noteworthy. Jäger's investigations on the extinct vertebrate fauna of Würtemberg, published between 1824 and 1839, were an important advance. To Plieninger's researches in the same region, 1834–'44, we owe the discovery of the first Triassic mammal (*Microlestes*), as well as important information in regard to Labyrinthodonts. Kaup's researches on fossil mammals, 1832–'41, brought to light many interesting forms, and to him we are indebted for the generic name *Dinotherium*, and excellent descriptions of the remains then known.

Count Münster's "Beiträge zur Petrifactenkunde," published 1843–'46, contained several valuable papers on fossil vertebrates; and the separate papers by the same author are of interest. Andreas Wagner wrote on Pterosaurians in 1837, and later gave the first description of fossil mammals of the Tertiary of Greece, 1837–'40. Johannes Müller published an important illustrated work on the Zeuglodonts in 1849, and various notable memoirs; and Quenstedt interesting descriptions of fossil reptiles, as well as other papers of much value. Rütimeyer's suggestive memoirs are widely known.

Hermann von Meyer's contributions to vertebrate paleontology are by far the most important published in Germany during the period we are now considering. From 1830 his investigations on this subject were continuous for nearly forty years, and his various publications are all of value. His "Beiträge zur Petrifactenkunde," 1831–'33, contains a series of valuable memoirs. His "Palæologica," issued in 1832, includes a synopsis of the fossil vertebrates then known, with much original matter. His great work, "Zur Fauna der Vorwelt," 1845–'60, includes a series of monographs invaluable to the student of vertebrate paleontology. This work, as well as his other chief publications, was illustrated with admirable plates from his own drawings. Other memoirs by this author will be found in the "Palæontographica," of which he was one of the editors. In the many volumes of this publication, which began in 1851, and is still continued, will be found much to interest the investigator in any branch of paleontology.

The "Palæontographical Society of London," established in 1847, has also issued a series of volumes containing valuable memoirs in various branches of paleontology. These two publications together are a storehouse of knowledge in regard to extinct forms of animal and vegetable life.

It may be interesting here to note briefly the use of general terms in paleontology, as the gradual progress of the science was indicated to some extent in its terminology. At first, and for a long time, the name "*fossil*" was appropriately used for objects dug from the earth, both minerals and organic remains. The term "oryctology," having essentially the same meaning, was also used for this branch of study. For a long period, too, the termination *ites* (λίθος, a stone) was applied to fossils to distinguish them from the corresponding living forms; as, for instance, "*ostracites*," used by Pliny. At a later date the general name "figured stones" (*lapides figurati*) was extensively used; and, less frequently, "deluge-stones" (*lapides diluviani*). The term "organized fossils" was used to distinguish fossils from minerals when the real difference became known, although the name "*reliquia*" was sometimes employed. The term "petrifactions" (*petrificata*) was defined by John Gesner in his work on fossils in 1758, and was afterward extensively used. Paleontology is comparatively a modern term, having only come into use only within the last half century. It was introduced about 1830, and soon was generally adopted in France and England; but in Germany it met with less favor, though used to some extent.

It would be interesting, too, did time permit, to trace the various opinions and superstitions held at different times in regard to some of the more common fossils, for example the Ammonite or the Belemnite—of their supposed celestial origin; of their use as medicine by the ancients, and in the East to-day; of their marvelous power as charms among the Romans, and still among the American Indians. It would be instructive, also, to compare the various views expressed by students in science concerning some of the stranger extinct forms—for instance, the Nummulites, among Protozoa; the Rudistes, among Mollusks; or the Mosasaurus, among reptiles. Dissimilar as such views were, they indicate in many cases gropings after truth—natural steps in the increase of knowledge.

The third period in the history of paleontology, which, as I have said, began with Cuvier and Lamarck at the beginning of the present century, forms a natural epoch extending through six decades. The definite characteristics of this period, as stated, were dominant during all this time, and the progress of paleontology was commensurate with that of intelligence and culture.

For the first half of this period, the marvelous discoveries in the Paris Basin excited astonishment and absorbed attention; but the real significance and value of the facts made known by Cuvier, Lamarck, and William Smith were not appreciated. There was still a strong tendency to regard fossils merely as interesting objects of natural history, as in the previous period, and not as the key to profounder problems in the earth's history. Many prominent geologists were still endeavoring to identify formations in different countries by their mineral characters rather than by the fossils imbedded in them. Such names as "Old Red Sandstone" and "New Red Sandstone" were given in accordance with this opinion. Humboldt, for example, attempted to compare the formations of South America and Europe by their mineral features, and doubted the value of fossils for this purpose. In 1823 he wrote as follows: "Are we justified in concluding that all formations are characterized by particular species? that the fossil shells of the chalk, the muschelkalk, the Jura limestone, and the Alpine limestones are all different? I think this would be pushing the induction much too far."* Jameson still thought minerals more important than fossils for characterizing formations; while Bakewell, later yet, defines paleontology as comprising "fossil zoölogy and fossil

* "Essai Géognostique sur le Gisement des Roches," p. 41.

botany, a knowledge of which may appear to the student as having little connection with geology."

During the later half of the third period, greater progress was made, and before its close geology was thoroughly established as a science. Let us consider for a moment what had really been accomplished up to this time.

It had now been proved beyond question that portions at least of the earth's surface had been covered many times by the sea, with alternations of fresh water and of land; that the strata thus deposited were formed in succession, the lowest of the series being the oldest; that a distinct succession of animals and plants had inhabited the earth during the different geological periods; and that the order of succession found in one part of the earth was essentially the same in all. More than 30,000 new species of extinct animals and plants had now been described. It had been found, too, that from the oldest formations to the most recent, there had been an advance in the grade of life, both animal and vegetable, the oldest forms being among the simplest, and the higher forms successively making their appearance.

It had now become clearly evident, moreover, that the fossils from the older formations were all extinct species, and that only in the most recent deposits were there remains of forms still living. The equally important fact had been established that in several groups of both animals and plants the extinct forms were vastly more numerous than the living, while several orders of fossil animals had no representatives in modern times. Human remains had been found mingled with those of extinct animals, but the association was regarded as an accidental one by the authorities in science; and the very recent appearance of man on the earth was not seriously questioned. Another important conclusion reached, mainly through the labors of Lyell, was, that the earth had not been subjected in the past to sudden and violent revolutions; but the great changes wrought had been gradual, differing in no essential respect from those still in progress. Strangely enough, the corollary to this proposition, that life, too, had been continuous on the earth, formed at that date no part of the common stock of knowledge.

In the physical world the great law of "correlation of forces" had been announced and widely accepted; but, in the organic world, the dogma of the miraculous creation of each separate species still held sway, almost as completely as when Linnæus declared, "There are as many different species as there were different forms created in the beginning by the Infinite Being." But the dawn of a new era was already breaking, and the third period of paleontology we may consider now at an end.

Just twenty years ago, science had reached a point when the belief in "special creations" was undermined by well-established facts, slowly accumulated. The time was ripe. Many naturalists were working at the problem, convinced that evolution was the key to the present and the past. But how had Nature brought this change about? While others pondered, Darwin spoke the magic words—"*natural selection*," and a new epoch in science began.

The fourth period in the history of paleontology dates from this time, and is the period of to-day. One of the main characteristics of this epoch is the belief that *all life, living and extinct, has been evolved from simple forms.* Another prominent feature is the accepted fact of *the great antiquity of the human race.* These are quite sufficient to distinguish this period sharply from those that preceded it.

The publication of Charles Darwin's work on the "Origin of Species," November, 1859, at once aroused attention, and started a revolution which has already in the short space of two decades changed the whole course of scientific thought. The theory of "natural selection," or, as Spencer has happily termed it, the "survival of the fittest," had been worked out independently by Wallace, who justly shares the honor of the discovery. We have seen that the theory of evolution was proposed and advocated by Lamarck, but he was before his time. The anonymous author of the "Vestiges of Creation," which appeared in 1844, advocated a somewhat similar theory, which attracted much attention, but the belief that species were immutable was not sensibly affected until Darwin's work appeared.

The difference between Lamarck and Darwin is essentially this: Lamarck proposed the theory of evolution; Darwin changed this into a doctrine, which is now guiding the investigations in all departments of biology. Lamarck failed to realize the importance of time, and the interaction of life on life. Darwin, by combining these influences with those also suggested by Lamarck, has shown *how* the existing forms on the earth may have been derived from those of the past.

This revolution has influenced paleontology as extensively as any other department of science, and hence the new period we are discussing. In the last epoch, species were represented independently, by parallel lines; in the present period, they are indicated by dependent, branching lines. The former was the analytic, the latter is the synthetic period. To-day, the animals and plants now living are believed to be genetically connected with those of the distant past; and the paleontologist no longer deems species of the first importance, but seeks for relationships and genealogies, connecting the past with the present. Working in this spirit, and with such a method, the advance during the last decade has been great, and is an earnest of what is yet to come.

The progress of paleontology in Great Britain during the present period has been great, and the general interest in the science much extended. The views of Darwin soon found acceptance here. Next to his discovery of "natural selection," Darwin was fortunate in having so able and bold an expounder as Huxley, who was one of the first to adopt his theory and give it a vigorous support. Huxley's masterly researches have been of great benefit to all departments of biology, and his contributions to paleontology are invaluable. Among the latter, his original investigations on the relations of birds and reptiles are especially noteworthy. His various memoirs on extinct reptiles, amphibians, and fishes belong to the permanent literature of the subject. The important researches of Owen on the fossil vertebrates have been continued to the present time. He has added largely to his previous publications on the British fossil reptiles, birds, and mammals, the extinct reptiles of South Africa, and the post-Tertiary birds of New Zealand. His description of the *Archæopteryx*, near the beginning of the period, was a most welcome contribution.

The investigations of Egerton on fossil fishes have likewise been continued with important results. Busk, Dawkins, Flower, and Sanford have made valuable contributions to the history of fossil mammals. Bell, Günther, Hulke, Lankester, Newton, Powrie, Miall, Traquair, and Seely have made notable additions to our knowledge of reptiles, amphibians, and fishes. Among invertebrates, the Crustacea have been especially studied by Jones, Salter, and Woodward. Davidson, Etheridge, Lycett, Morris, Phillips, Wood, and Wright have continued their researches on the mollusks; Duncan, Nicholson, and others have investigated the extinct corals; and Binney, Carruthers, and Williamson the fossil plants. Numerous other important contributions have been made to the science in Great Britain during the present period.

On the Continent the advance in paleontology has, during the last two decades, been equally great. In France, Gervais continued his memoirs on extinct vertebrates nearly to the present date; while Gaudry has published several volumes on the subject that are models for all students of the science. His work on the fossil animals of Greece is a perfect monograph of its kind, and his later publications are all of importance. Lartet's various works are of permanent value, and his application of paleontology to archæology brought notable results. The volume of Alphonse Milne-Edwards on fossil Crustacea was a fit supplement to Brongniart and Desmarest's well-known work; while his grand memoir on fossil birds deserves to rank with the classic volumes of Cuvier. Duvernoy, Filhol, Hébert, Sauvage, and others have also published interesting results on fossil vertebrates.

Van Beneden's researches on the fossil vertebrates of Belgium have produced results of great value. Pictet, Rütimeyer, and Wiedersheim in Switzerland; Bianconi, Carnalia, Forsyth-Major, and Sismonda in Italy; and Nodot in Spain, have likewise published important memoirs. The extinct vertebrates have been studied in Germany by Von Meyer, Carus, Fraas, Giebel, Heckel, Haase, Hensel, Kayser, Kner, Ludwig, Peters, Portis, Maack, Salenka, Zittel, and many others; in Holland by Winkler; in Denmark by Reinhardt; and in Russia by Brandt and Kowalewsky.

The fossil invertebrates have been investigated with care by D'Archiac, D'Orbigny, Bayle, Fromentel, Oustalet, and others in France; Desor, Loriol, Mayer, Ooster, and Roux in Switzerland; Capellini, Massalongo, Michellotti, Meneghini, and Sismonda in Italy; Barrande, Benecke, Beyrich, Dames, Dorn, Ehlers, Geinitz, Giebel, Gümbel, Feistmantel, Hagen, Von Hauer, Von Heyden, Von Fritsch, Laube, Oppel, Quenstedt, Roemer, Schlüter, Suess, Speyer, and Zittel in Germany. The fossil plants have been studied in these countries by Massalongo, Saporta, Zigno, Fiedler, Goldenberg, Gehler, Heer, Göppert, Ludwig, Schimper, Schenk, and many others.

Among the recent researches in paleontology in other regions may be mentioned those of Blanford, Feistmantel, Lydekker, and Stoliczka in India; Haast and Hector in New Zealand; and Krefft and McCoy in Australia—all of whom have published valuable results.

Of the progress of paleontology in America I have thus far said nothing, and I need now say but little, as many of you are doubtless familiar with its main features. During the first and second periods in the history of paleontology, as I have defined them, America, for most excellent reasons, took no part. In the present century, during the third period, appear the names of Bigsby, Green, Morton, Mitchell, Rafinesque, Say, and Troost, all of whom deserve mention. More recently the researches of Conrad, Dana, Deane, DeKay, Emmons, Gibbes, Hitchcock, Holmes, Lea, McChesney, Owen, Redfield, Rogers, Rominger, Shumard, Swallow, and many others have enlarged our knowledge of the fossils of this country.

The contributions of James Hall to the invertebrate paleontology of this country form the basis of our present knowledge of the subject. The extensive labors of Meek in the same department are likewise entitled to great credit, and will form an important chapter in the history of the science. The memoirs of Billings, Gabb, Scudder, White, and Whitfield are numerous and important; and the publications of Derby, Hartt, Hyatt, James, Miller, Shaler, Rathbun, Vogdes, Whiteaves, and Winchell, are also of value. To Dawson, Lesquereux, and Newberry we mainly owe our present knowledge of the fossil plants of this country.

The foundation of our vertebrate paleontology was laid by Leidy, whose contributions have enriched nearly every department of the subject. The numerous publications of Cope are well known. Agassiz, Allen, Baird, Dawson, Deane, DeKay, Emmons, Gibbes, Harlan, Hitchcock, Jefferson, Lea, Le Conte, Newberry, Redfield, St. John, Warren, Whitney, Worthen, Wyman, and others have all added to our knowledge of American fossil vertebrates. The chief results in this department of our subject I have already laid before you on a previous occasion, and hence need not dwell upon them here.

In this rapid sketch of the history of paleontology I have thought it best to speak of the earlier periods more in detail, as they are less generally known, and especially as they indicate the growth of the science, and the obstacles it had to surmount. With the present work in paleontology, moreover, you are all more or less familiar, as the results are now part of the current literature. To assign every important discovery to its author would have led me far beyond my present plan. I have only endeavored to indicate the growth of the science by citing the more prominent works that mark its progress, or illustrate the prevailing opinions and state of knowledge at the time they were written.

In considering what has been accomplished, directly or indirectly, it is well to bear in mind that without paleontology there would have been no science of geology. The latter science originated from the study of fossils, and not the reverse, as generally supposed. Paleontology, therefore, is not a mere branch of geology, but the foundation on which that science mainly rests. This fact is a sufficient excuse, if one were wanting, for noting the early opinions in regard to the changes of the earth's surface, as these changes were first studied to explain the position of fossils. The investigation of the latter first led to theories of the earth's formation, and thus to geology. When speculation replaced observation, fossils were discarded, and for a time the mineral characters of strata were thought to be the key to their position and age. For some time after this, geologists, as we have seen, apologized for using fossils to determine formations, but for the last half century their value for this purpose has been fully recognized.

The services which paleontology has rendered to botany and zoölogy are less easy to estimate, but are very extensive. The classification of these sciences has been rendered much more complete by the intercalation of many intermediate forms. The probable origin of various living species has been indicated by the genealogies suggested by extinct types; while our knowledge of the geographical distribution of animals and plants at the present day has been greatly improved by the facts brought out in regard to the former distribution of life on the globe.

Among the vast number of new species which have been added are the representatives of a number of new orders entirely unknown among living forms. The distribution of these extinct orders among the different classes is interesting, as they are mainly confined to the higher groups. Among the fossil plants no new orders have yet been found. There are none known among the Protozoa or the Mollusca. The Radiates have been enriched by the extinct orders of Blastoidea, Cystidea, and Edrioasterida; and the Crustaceans by the Eurypterida and Trilobita. Among the vertebrates, no extinct order of fossil fishes has yet been found; but the amphibians have been enlarged by the important order Labyrinthodonta. The greatest additions have been among the reptiles, where the majority of the orders are extinct. Here we have at the present date the Ichthyosauria, Sauranodontia, Plesiosauria, and Mosasauria, among the marine forms; the Pterosauria, including the Pteranodontia, containing the flying forms; and the Dinosauria, including the Sauropoda—the giants among reptiles; likewise the Dicynodontia, and probably the Theriodontia, among the terrestrial forms. Although but few fossil birds have been found below the Tertiary, we have already among the Mesozoic forms three new orders: the Saururæ, represented by *Archæopteryx;* the Odontotormæ, with *Ichthyornis* as the type; and the Odontolcæ, based upon *Hesperornis;* all of these orders being included in the sub-class Odontornithes, or toothed birds. Among mammals, the new groups regarded as orders are the Toxodontia and the Dinocerata, among the Ungulates; and the Tillodontia, including strange Eocene mammals whose exact affinities are yet to be determined.

Among the important results in vertebrate paleontology, are the genealogies, made out with considerable probability, for various existing animals. Many of the larger mammals have been traced back through allied forms in a closely connected series to early Tertiary times. In several cases the series are so complete that there can be little doubt that the line of descent has been established. The evolution of the horse, for example, is to-day demonstrated by the specimens now known. The demonstration in one case stands for all. The evidence in favor of the genealogy of the horse now rests on the same foundation as the proof that any fossil bone once formed part of the skeleton of a living animal. A special creation of a single bone is as probable as the special creation of a single species. The method of the paleontologist in the investigation of the one is the method for the other. The only choice lies between *natural derivation* and *supernatural creation.*

For such reasons it is now regarded among the active workers in science as a waste of time to discuss the truth of evolution. The battle on this point has been fought and won.

The geographical distribution of animals and plants, as well as their migrations, has received much new light from paleontology. The fossils found in some natural divisions of the earth are related so closely to the forms now living there, that a genetic connection between them can hardly be doubted. The extinct Marsupials of Australia and the Edentates of South America are well-known examples. The Pliocene hippopotami of Asia and the south of Europe point directly to migrations from Africa. Other similar examples are numerous. The fossil plants of the Arctic region prove the existence of a climate there far milder than at present, and recent researches at least render more probable the suggestion, made long ago by Buffon, in his "Epochs of Nature," that life began in the polar regions, and by successive migrations from them the continents were peopled.

The great services which comparative anatomy rendered to paleontology at the hands of Cuvier, Agassiz, Owen, and others have been amply repaid. The solution of some of the most difficult problems in anatomy has received scarcely less aid from the extinct forms discovered than from embryology; and the two lines of research supplement each other. Our present knowledge of the vertebrate skull, the limb-arches, and the limbs, has been much enlarged by researches in paleontology. On the other hand, the recent labors of Gegenbaur, Huxley, Parker, Balfour, and Thacher will make clear many obscure points in ancient life.

One of the important results of recent paleontological research is the law of brain-growth, found to exist among extinct mammals, and to some extent in other vertebrates. According to this law, as I have briefly stated it elsewhere, "all Tertiary mammals had small brains. There was, also, a gradual increase in the size of the brain during this period. This increase was confined mainly to the cerebral hemispheres, or higher portions of the brain. In some groups, the convolutions of the brain have gradually become more complicated. In some, the cerebellum and the olfactory lobes have even diminished in size." More recent researches render it probable that the same general law of brain-growth holds good for birds and reptiles from the Mesozoic to the present time. The Cretaceous birds, that have been investigated with reference to this point, had brains only about one third as large in proportion as those nearest allied among living species. The Dinosaurs from our Western Jurassic follow the same law, and had brain-cavities vastly smaller than any existing reptiles. Many other facts point in the same direction, and indicate that the general law will hold good for all extinct vertebrates.

Paleontology has rendered great service to the more recent science of archæology. At the beginning of the present period, a reëxamination of the evidence in regard to the antiquity of the human race was going on, and important results were soon attained. Evidence in favor of the presence of man on the earth at a period far earlier than the accepted chronology of six thousand years would imply, had been gradually accumulating, but had been rejected from time to time by the highest authorities. In 1823, Cuvier, Brongniart, and Buckland, and later, Lyell, refused to admit that human relics, and the bones of extinct animals found with them, were of the same geological age, although experienced geologists, such as Boué and others, had been convinced by collecting them. Christol, Serres, and Tournal, in France, and Schmerling in Belgium, had found human remains in caves, associated closely with those of various extinct mammals, and other similar facts were on record.

Boucher de Perthes, in 1841, began to collect stone implements in the gravels of the valley of the Somme, and in 1847 published the first volume of his "Antiquités Celtiques." In this work he described the specimens he had found, and asserted their great antiquity. The facts as presented, however, were not generally accepted. Twelve years later, Falconer, Evans, and Prestwich examined the same localities with care, became convinced, and the results were published in 1859 and 1860. About the same time, Gaudry, Hébert, and Desnoyers also explored this valley, and announced that the stone implements there were as ancient as the mammoth and rhinoceros found with them. Explorations in the Swiss lakes and in the Danish shell-heaps added new testimony bearing in the same direction. In 1863 appeared Lyell's work on the "Geological Evidences of the Antiquity of Man," in which facts were brought together from various parts of the world, proving beyond question the great age of the human race.

The additional proof since brought to light has been extensive, and is still rapidly increasing. The Quaternary age of man is now generally accepted. Attempts have recently been made to approximate in years the time of man's first appearance on the earth. One high authority has estimated the antiquity of man merely to the last glacial epoch of Europe as 200,000 years; and those best qualified to judge would, I think, regard this as a fair estimate.

Important evidence has likewise been adduced of man's existence in the Tertiary, both in Europe and America. The evidence to-day is in favor of the presence of man in the Pliocene of this country. The proof offered on this point by Professor J. D. Whitney in his recent work* is so strong, and his careful, conscientious method of investigation so well known, that his conclusions seem irresistible. Whether the Pliocene strata he has explored so fully on the Pacific coast corresponds strictly with the deposits which bear this name in Europe, may be a question requiring further consideration. At present, the known facts indicate that the American beds containing human remains and works of man are as old as the Pliocene of Europe. The existence of man in the Tertiary period seems now fairly established.

In looking back over the history of paleontology, much seems to have been accomplished; and yet the work has but just begun. A small fraction only of the earth's surface has been examined, and two large continents are waiting to be explored. The "imperfection of the geological record," so often cited by friends and foes, still remains,

* "Auriferous Gravels of the Sierra Nevada of California," 1879.

although much improved; but the future is full of promise. In filling out this record, America, I believe, will do her full share, and thus aid in the solution of the great problems now before us.

I have endeavored to define clearly the different periods in the history of paleontology. If I may venture, in conclusion, to characterize the present period in all departments of science, its main feature would be a *belief in universal laws*. The reign of Law, first recognized in the physical world, has now been extended to Life as well. In return, Life has given to inanimate Nature the key to her profounder mysteries—Evolution, which embraces the universe.

What is to be the main characteristic of the next period? No one now can tell. But, if we are permitted to continue in imagination the rapidly converging lines of research pursued to-day, they seem to meet at the point where organic and inorganic nature become one. That this point will yet be reached, I can not doubt.

INTEROCEANIC CANAL ROUTES.*

By CHARLES DE FOURCY, C. E.

INSTEAD of delaying the discussion by a series of resolutions, I ask your permission to develop, at some length, the question as it strikes me in its entirety; and, that you may know the drift of my argument, I will begin by stating the conclusion at which I have arrived, viz., that the Interoceanic Canal should be constructed in the Isthmus of Panama, between the Bay of Colon and the Gulf of Panama. This canal, using merely the water of the ocean, should have no appreciable current, and it should be of the same level as the average tide in the Bay of Colon, where the rise and fall are hardly perceptible. To show you why I am firmly convinced of this, I will enter with some detail into the labors of your second sub-committee, over which I had the honor of presiding, and of which you warmly received the report presented by M. Voisin Bey. The report of this sub-committee, which is to be printed, will show you how impartially, with what scrupulous care, with what exhaustive discussion, and finally with what unanimity its decisions were taken. I am wrong in saying *decisions*, for none were taken. Of every one of the plans submitted then to its examination, and now to your vote, it showed up the advantages and the difficulties, the strong and the weak side; it prepared no form of resolution, giving to each of its members full liberty to express an opinion, as you can now. It is therefore in my personal name

* The Interoceanic Canal. Speech delivered by M. Charles de Fourcy before the Technique Committee of the Paris International Congress, on May 28, 1879.

and on my own responsibility that I offer you my solution and the following explanations.

I shall examine successively the various plans for lock-canals, showing which one seems to me to be the best, if such a system should be regarded as most advantageous.

I shall compare, in the same way, the projects for a tide-level canal. Finally, I shall compare the best plan for a lock canal with the best one for a tide-level canal.

[PRINCIPAL PROJECTED ROUTES OF THE INTEROCEANIC CANAL EXAMINED BY THE INTERNATIONAL CONGRESS. (See map on the following page.)

1. *Plan by the Isthmus of Tehuantepec.* Length, 148 miles; number of locks, 120; time for passage, twelve days.

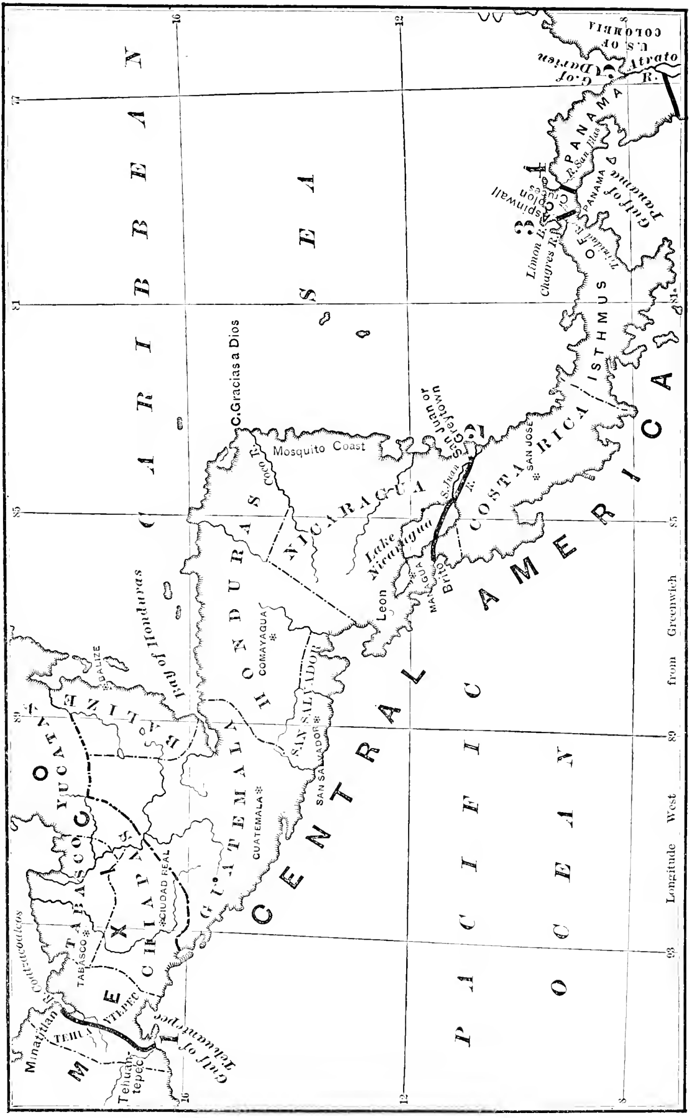
2. *Plan by the Lake of Nicaragua.* Length, 180 miles; number of locks, 17; time for passage, four and a half days.

3. *Plan for Level-water and Deep-cut Canal by the Isthmus of Panama.* Length, 45 miles; time for passage, two days.

4. *Plan by the Isthmus of San Blas.* Length, 33 miles; time for passage, one day.

5. *Plan by Atrato-Napipi.* Length, 179 miles; number of locks, 3; time for passage, three days.—EDITOR.]

COMPARISON OF THE DIFFERENT PLANS FOR A LOCK-CANAL.—I shall at once refuse a canal by the line of Tehuantepec, although it seems to me to be one of the easiest to be constructed: but it would demand a great number of locks; the passage through it would take a great deal of time comparatively; and, moreover, the canal would pass through a country which, from the unstable nature of the soil, is very undesirable for such a work. We have been told, I am aware, that these "movements," which I hardly dare to call earthquakes, were not to be feared; that during these "movements," to which the inhabitants of the country are well accustomed, sometimes in the walls of houses and of public buildings, cracks would appear wide enough for the light to be seen through them, but soon these cracks would be closed to crevices, mere lines, and that then the buildings threatened for the time would again become solid until there was a new "movement." These explanations do not entirely satisfy me, and I admit that such possibilities seem to me very objectionable for a canal with locks; simple crevices in the lateral walls, especially in the raised portions, would seriously compromise the working of the gates, and might necessitate, when least expected, long and costly repairs, and, what is more serious still, interrupt for a number of days, entire months perhaps, the passage of ships. Can one, therefore, readily imagine what would happen if fleets of vessels, becoming more numerous every day, should find themselves stopped in their passage, some on the Pacific and others on the Atlantic side, and compelled, in order to reach their destination, to continue their journey by Cape Horn or the Straits of Magellan, to



A GENERAL MAP OF THE ISTHMUS OF CENTRAL AMERICA, SHOWING THE VARIOUS PROJECTED ROUTES FOR THE INTEROCEANIC CANAL.

which they were no longer accustomed? What would then become of the insurance which had been arranged for the expected passage through a canal which was no longer of any use?

If, in speaking of Tehuantepec, which line, however, is no longer thought of for a canal, I have somewhat enlarged on the inconveniences which would arise from earthquakes, it is because they also appear to me to apply to the canal by Nicaragua, and to put it out of consideration, even were there no other reasons.

Let us look, all the same, at other contingencies which are noticeable at Nicaragua.

It would be a long and difficult task to actually begin the work, because, before the great dockyards of the canal could be built, it would be necessary to make a harbor at Greytown, the success of which does not appear to be assured, and which at any rate would be very expensive.

Starting at this harbor, the canal, when leaving the San Juan River, would for several kilometres be suspended over the valley by immense dikes holding continuously a weight of water 8·50 metres high. There the slightest leak would become a breach, any breach a serious rupture, and any rupture a complete disaster. At what possible expense could the absolute security of these great dikes be assured?

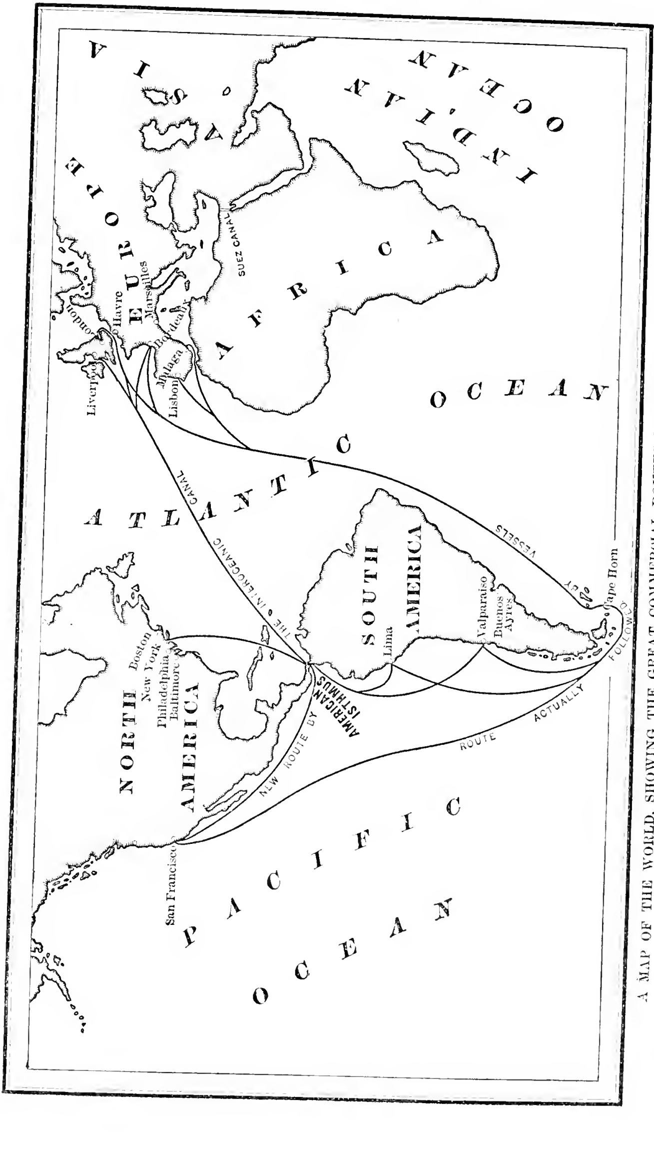
To continue: we enter the San Juan River, kept in bounds by a large dam, which, however, is not enough to assure everywhere sufficient depth of water in the shallowest parts; where there is not depth enough it would be necessary to blow up or excavate by dredges a channel one hundred metres wide by eight and a half metres deep. To make this channel would be difficult, to maintain it against what would constantly come in to fill it up might be still more so.

Let us go on until we reach the lake; here comes another difficulty. At the place where the San Juan leaves it, other torrents bring sand into it, and also mud to a considerable extent. A new bar would have to be dredged, but probably only for a time; a channel would have to be kept open in an immense sliding sand-bank by very long and costly dikes, an objection which does not seem to have been provided for in any of the plans offered.

The passage of the lake seems easy; the cut to be made to reach the Pacific offers no remarkable difficulties; but this descent, on account of its short length, can only be done by locks close together, and locks so arranged offer for a quick movement of vessels serious objections, and necessitate a considerable loss of time.

Without dwelling too much on this subject, let us be content to take as an example the Caledonian Canal. In visiting it some years ago, as an engineer and a tourist, I was struck at seeing that, to avoid passing through it, a reshipment was considered preferable. I have said enough to show my reasons for refusing to accept the Nicaragua plan.

Next comes the project by Panama with locks. Here, as if



A MAP OF THE WORLD, SHOWING THE GREAT COMMERCIAL ROUTES TRIBUTARY TO THE PROPOSED CANAL.

Nature herself had wished to get ready for man's work, the soil, as at Darien, has for a long time been free from earthquakes. The study for a lock-canal was made in 1845 by Garella, Engineer-in-Chief of Mines, sent there on a mission by the French Government. I desire to bring to your attention this name, which has been too much forgotten, because this mission, courageously and conscientiously performed, honors not only the man who carried it out, but also the administration which confided it to him, and because his splendid studies seem still to be the best that have been made there, and which should now be taken, in part at least, if it should be desirable to connect the two oceans by a lock-canal.

Condensing this too long *exposé* of the situation, I conclude by saying that, of all the lock-canals studied or proposed, the least objectionable is that which would go from the Bay of Limon to the Gulf of Panama.*

Comparison of the Tide-level Canals.—Let us now examine the different plans for level-water canals which have been presented to our consideration.

The one which is called Atrato-Napipi would have our entire sympathy if we could thus adequately express our appreciation of the devotion of Commander Selfridge, who for several years has been exploring that part of the country, so wild and difficult of access; and yet, interesting as this plan seems to be, we must absolutely refuse to accept it.

The Atrato is neither the Mississippi nor the Amazon, but it is, nevertheless, a very powerful river, with heavy overflows, which bring to its mouth immense deposits, forming a great bar. To make artificially across this bar, and to keep it always open, a channel wide enough and deep enough for the largest vessels, is a very great undertaking, the success of which, however, should not be regarded as impossible or even as improbable. But still there is no instance of a work of such importance, and we find ourselves facing a problem the solution of which—a very laborious and very expensive matter—is by no means certain.

With such an obstacle before us, and with no certainty of overcoming it, would it be prudent to undertake a canal, the expense of which is estimated at more than eleven hundred million francs?

On the other hand, the canal, properly considered, would be on the Pacific side a branch of the Atrato, and, to a great degree, unless it was entirely shut off by a sluice-gate, subjected to the variations of the Atrato. Would it be, moreover, easy to keep up, where it branches from the river, a channel with a depth always assured of eight and a half metres? Would not the point of branching, under any circumstances, be liable to be filled up with sand, which doubtless it would be difficult and expensive to keep continually removed?

* This also is the plan recommended by General Totten.

While keeping honorably the name of Commander Selfridge in our thoughts, with all regret we must put out of sight a plan the success of which is at best doubtful, while its cost would be relatively enormous.

Shall we now take up the San Blas project? This line is the shortest which joins the two oceans, but to carry it out a harbor must be built on the Atlantic, and then you soon find yourself facing a mountain-chain which has to be passed by a tunnel sixteen kilometres long; next you come to the Bayano, with elbows in its course too square to be straightened out, and a bar also on the Pacific side, which it is not certain could be mastered. The expense calculated for all this is fourteen hundred million francs.

The plan of a tunnel does not frighten M. Favre,* the contractor of the one through the St. Gothard Mountain, nor would it frighten me, especially if he were willing to undertake it; but shipmasters do not take kindly to so long a passage without fresh air and the light of day; and, although it is proposed to give electric light instead, which will be as bright as day, there would still be an unconquerable antipathy against this project.

For these reasons I decline to accept the San Blas plan, which, moreover, has only been hastily surveyed, and it is possible that a more careful examination of it would bring to light other difficulties of which we are not now cognizant.

Therefore, throwing out other plans, we find ourselves in a position to examine the project of a tide-level canal from Colon (Aspinwall) to Panama, a project which has been so patiently and courageously explored and worked out by Messrs. Wyse and Reclus, lieutenants of the French navy.

This plan demands two changes, important and absolutely necessary, the success of which, while not easy, seems to me perfectly certain.

In the first place, a large part of the ship-canal must be made in the valley of the river Chagres, a river so inconvenient and dangerous that we must have nothing to do with it, at no matter what cost, if we desire that the canal should have a regular water-level—a condition absolutely necessary for its success.

For this, two plans offer themselves. The first is to keep the canal above any possibilities of overflow. Theoretically, nothing is easier; the railroad, now in operation between Colon (Aspinwall) and Panama, which the canal should follow, and as near as possible, is above the overflow of the Chagres. By prolonging the level of this roadway to the sides of the valley a winding line would be traced, bringing us to the place beyond which the canal can be constructed, without danger from

* This great engineer died at his post in the St. Gothard Tunnel, from a stroke of apoplexy, a short time after the adjournment of the Paris Congress, of which he was one of the most valued members.

the highest overflow of the water; but this line will, doubtless, be too tortuous to enable one to follow it correctly, or to be always above it; one should, in order to obtain reasonably straight lines, or curves not too sharp, bring the canal partially to the *Thalweg* of the valley; it will therefore be necessary at several places to change the bed of the Chagres, the bends of which multiplied would encroach upon the route of the canal. But the land, coming from this partial changing of the line, as well as that which would come from digging out the canal itself, turned up to a moderate height, quite equal to the corresponding height of the embankment of the railroad, would make a dike which the water of the Chagres could not pass over. At the place where the line of the canal will necessarily cross the bed of the Chagres to fall into the Bay of Limon, the Chagres will be turned from its course to allow the canal to pass at its left.

On the other bank the river Trinidad, a left tributary of the Chagres, would be, on the contrary, kept on the right side of the canal, and, by means of an easy change of its course, would flow in the actual bed of the Chagres to that very river to the north of Limon Bay, taking therefore, to become itself a river, the river of which it was only a tributary. What, then, would be the expense of this radical change? We have not at hand all the details necessary to calculate it; but, allowing an expense of fifty million francs for this work, we think it would amply be provided for.

But, should this plan not prove successful, there is another suggested by Messrs. Wyse and Reclus, which is also perfectly feasible, and the expense of which can be more closely calculated. This is, to build over Cruces an immense reservoir, capable of holding more than six hundred cubic metres of water—that is to say, more than the volume of water which could possibly be formed during several days of the greatest overflows of the Chagres, which, we are told, amount to occasionally, but for a very short time, twelve hundred cubic metres a second. This work would cost twenty-five million francs, but it would free us from all apprehension of the devastation occasioned by this river, which at times becomes a torrent, for the letting it off under the reservoir would be done gradually and without danger into a bed arranged beforehand, leaving the canal always on the left. For opening this bed, which would not at all be the same one as that of the Chagres, for straightening it at different places, and for doing the same for the river Trinidad, seventeen million francs should amply suffice.

Freed, therefore, from all fear, nothing more remains but to regulate, I can say even to a few centimetres, the height of the water in the ship-canal; and then comes in the second change that we suggest to the plan of Messrs. Wyse and Reclus, which is, merely to provide against the occasionally very rapid currents which would come from the great rise and fall of the tide on the Pacific, which sometimes amount to six metres. This can easily be managed by a tide-barrier in such a way that the level of the water in the canal will be regulated by that of the Atlantic, which varies but very little.

With these two modifications that we have pointed out to the plan of Messrs. Wyse and Reclus, and in fixing at four kilometres the greatest length of the tunnel—which can probably be reduced in length when the work is actually in hand, and perhaps be entirely done away with by a deep cut—your first sub-committee, over-estimating perhaps the expense calculated, brings the sum total to somewhat less than eleven hundred million francs, including the interest on the capital embarked during the time of construction, and the working expenses capitalized at five per cent. I feel confident that this figure will not be exceeded, and I am even confident that it will not be reached. Indeed, it is well known that the building of the railroad from Colon (Aspinwall) to Panama did not cost much more than such a work would had it been done in Europe ; and here we shall have to aid us in putting up the great workshops of the canal, at short notice, a railroad already built, which is in excellent running order from one end to the other, and has a good harbor on either side.

I have said enough to show, I think—and here is the second point in the programme of my address—that, whatever may be the plan adopted, canal with locks or canal on a tide-level, it is from the Bay of Colon to the Gulf of Panama that it should go.

Comparison of the Tide-level Canal with the Lock-Canal.—Let us now compare the relative advantages of these two systems. In a technical point of view the preceding discussion would seem to make any further development superfluous. Moreover, have we not heard, in the first sittings of the committee, M. Cotard himself, an advocate, I believe, of the former system, declare without contradiction that, if the tide-level canal was possible and could be made to pay, it would be preferable to one with locks? Have we not heard and applauded the report of M. Fontane, the General Secretary of the Suez Canal Company, in which he tells you, in behalf of the Committee on Statistics, of which he is a member, that a tide-level canal is the only one that can supply the demands of the navigation of the entire world?

After having shown that the construction of a tide-level canal is possible, and under what conditions it is possible and assured, it would only remain to prove that it would pay. Here the fine report of M. Levasseur, in behalf of the Committee on Statistics, a report which you heartily applauded at the last meeting of the Congress, makes my task an easy one. The report declares and proves that, at the time when the canal should be opened, it can reasonably count upon a commerce of more than seven million tons. Very well, the Suez Canal, which cost almost five hundred million francs, with three million tons only, and subjected to demands which the Interoceanic Canal will not have to undergo, is proposing a diminution of its charges to only seven or eight francs for actual tonnage, a tariff which could easily be doubled without depriving the canal of a ton of the merchandise which is passing through it to-day. Under these conditions the Suez Canal is a prosperous enterprise. Its stock, which was issued at 500 francs, is now quoted at 750 francs, and its bonds, payable at only 500 francs, are sold for 570 francs.

Suppose, then, for the Interoceanic Canal an original outlay of double this sum, more than double, if you please, and put opposite this figure a traffic reduced in the first years to four million tons, instead of seven, and a charge of fifteen francs, which will be a very slight tax on commerce.

Can it therefore not be admitted that this great enterprise is of a kind to attract large capital seeking an advantageous investment? But these large sums will not be the only ones on which we can count. Let us not pay our century the poor compliment of supposing that everything is done on a mere money-making basis. The Interoceanic Canal will bring in subscribers from those who, captivated by the grandeur of the work, will wish to help it with their mite, without thinking whether or not they will get anything back. These subscribers—who will come from America, from Asia, and from Europe—these subscribers will have for their name legion. Once already, and under less favorable circumstances, they have answered the appeal of him who built the Suez Canal; they will not be wanting for the Interoceanic Canal Company, which will have as its chief and responsible head Ferdinand de Lesseps.

PREMATURE BURIALS.

By G. ERIC MACKAY.

THE difference between death and a state of trance—or, as the Germans put it, *Todt* and *Scheintodt*—has never been quite clearly understood by the generality of mankind. Society, which sometimes does its best for the living, does not always do its best for the dead (or those who appear to be dead), and he would be a bold man who, without statistics, should assert that men, women, and children are never, by any chance, buried alive. Are the bodies of the poor always examined with care before burial? Are deaths properly verified in days of epidemic, that is to say in days of social panic?

I propose in this article to call attention to a few instances of premature burials on the Continent of Europe: instances which involve stories of trance, or *Scheintodt*—a trance, the semblance of death, holding its sway over the human body for hours and days, and not merely for minutes, as in the case of ordinary fainting-fits. In days when land is dear, and burial rights are less sacred than the rights of builders and contractors, coffins have been opened with the pickaxe, in the act of converting cemeteries into streets and gardens. Here a grave has been discovered whose inmate has turned in its shroud; here a corpse clutching its hair in a strained and unnatural position: dead men and dead women lying in their graves as dead men never lie in a Christian land at the moment of burial. The presumption is, that these people have been legally murdered.

A few months ago a young and beautiful woman, on the eve of her marriage with the man she loved, was buried in the neighborhood of Lodi, in Piedmont, in accordance with the doctor's certificate. The doctor was of opinion that the girl had died from excitement—overjoy, it is said, at the prospect of being married, but the legal name for the catastrophe was disease of the heart, and with this verdict her place in society was declared vacant. When the first shovelful of earth was thrown down on the coffin, strange noises were heard proceeding therefrom, "as of evil spirits disputing over the body of the dead." The grave-diggers took to flight, and the mourners began praying; but the bridegroom, less superstitious than the others, insisted on the coffin being unnailed. This was done; but too late: the girl was found in an attitude of horror and pain impossible to describe; her eyes wide open, her teeth clinched, her hands clutching her hair. Life was extinct; but, when laid in her shroud the day before, her eyes were closed, her hands were folded on her breast as if in prayer.

The "Medical Academy" of Milan, in one of its weekly reports, published on Wednesday, March 22, 1848, quotes a case of trance which occurred to an ex-nun of the suppressed convent of St. Orsola, named Lucia Marini. The lady was taken ill, and, to all outward appearance, died: she was known to be subject to a peculiar kind of fit, which required peculiar treatment, and was staying at the time of the catastrophe in the house of a friend, who had been a nun. The *becchini* (grave-diggers, who in this case were the undertakers) insisted on burying the body before night; the surviving ex-nun remonstrated, urging that she must first try the effect of friction and mustard-plasters applied to feet and stomach. Fearing to lose their fee, the men of death waxed wroth in their contention, and, seizing the body by the shoulders, were about to drag it out of its bed, when the "dead lady," moaning and muttering inarticulate sounds, turned restlessly on her pillow. The friend of Lucia Marini broke out into prayers, interrupted by tears; the men let go their hold, and one of them (the elder of the two) crossed himself devoutly. The other, with a great oath, declared it was "spasms"; the dead, in his opinion, being liable to convulsive movements if not properly straightened. But humanity prevailed over ignorance, and cupidity gave way to medical skill. The lady was thoroughly revived by a medical practitioner of the neighborhood, and lived for many a long day to tell the story of her escape from the tomb.

Another case in point is that of Cardinal Espinosa, sometime President of Castile. Philip II., King of Spain, one day, in a moment of irritation, addressed him as follows: "Cardinal, take heed! You are speaking to the President of Castile." The Cardinal understood that he was dismissed from office (the King being his own president), and fell to the ground as if stunned. The pulse showed no signs of life; the parted lips emitted no breath—the King's wrath had slain his minister. It was decided that the unfortunate Cardinal should be cut open and embalmed. The surgeon arrived and commenced his operations, when lo! in the midst of the cutting the patient awoke, and, with screams of agony, attempted to struggle with his operator! But it was too late. The wounds were mortal, and the Cardinal expired before the comforts of religion could be administered to him.

In some instances the victims of trance have been known to rise out of their coffins. A case is recorded of a young lady in Leipsic, who, being reported dead during a nervous attack, was placed in her coffin in her parents' house, and there kept duly dressed for the grave, with the lid of the coffin still unnailed. While the family were at supper she appeared in her winding-sheet at the parlor-door, pale and frightened, but fair to see, as before her supposed death. Father and mother and sisters started up with cries of horror, and rushed out of the room by another door, believing her to be a ghost. It was only after a long interval, during which they entered and found her at table, eating and drinking, that they persuaded themselves that the girl still lived. They found her coffin empty; *ergo*, the ghost in the parlor was a living soul! The doctor, the priest, and the undertaker saw the error of their ways, and the deed was canceled which declared the lady a corpse. On the following year another deed was made out for the same lady, and the same priest officiated, but not the doctor or the undertaker. The lady was married, and lived to be the mother of many children.

But let us go back a century or two in these inquiries. We come upon the story of the Abbé Prévôt, author of "Manon Lescaut," and, earlier still, upon that of Petrarch.

Prévôt was found in a forest, one fine summer's day, in a state of complete unconsciousness. The village doctor, who examined the body, declared that life was extinct, and commenced what he was pleased to term his *post-mortem* examination. But at the first thrust of the knife the unlucky author awoke, and, with a piercing shriek, gave up the ghost. Bruchier, the biographer of Prévôt, deplores this event as a serious loss to literature. "Manon Lescaut," which Jules Janin complacently calls the "Paul and Virginia" of vice, might, he opines, have had a successor, if not a rival, from the same pen.

Petrarch, when a middle-aged man, lay in Ferrara twenty hours in a state of trance, and was to be buried on the completion of the time laid down by law, that is to say in four hours, when a sudden change of temperature caused him to start up in his bed. He complained of the draught and reprimanded his attendants. They had allowed a current of cold air to fall on his couch! Perhaps if the door had been kept shut, the poet, showing no signs of animation, would have been buried that day. Petrarch would have been defrauded of a large portion of his life, and the world would have lost, in consequence, some of its finest sonnets.

Misson, in his "Medical Anecdotes," tells a story of a lady who, in 1577, was buried alive in Cologne. This lady was the wife of a consul, and was placed in the family vault in gay attire, with rings on her fingers and a golden chain round her neck, as on her wedding-day. Robbers repaired to her grave at dead of night to steal her jewelry, and were taking the rings from her fingers, which were damp and swollen, when the lady awoke, and, sitting bolt upright, as if galvanized, stared and smiled at her visitors. One of the three men fell down in a fit, fearing the devil or his agency, and the others took to their heels "as if pursued by fiends." The lady walked home, and was received by her husband, first with fear, and afterward with transports of joy, and lived for many a long day in health and happiness. In the Church of the Holy Apostles at Cologne is a picture of the Consul's wife waking from the tomb, but the event is ascribed to a miracle, and death, and not a trance, is the subject of the picture.

But the resuscitated victims of apparent death do not always return safe and sound—hale in body and in mind—from the land of shadows. A carbineer in the Pope's service, named Luigi Vittori, was, not long ago, conveyed to the Roman hospital, and there, after a few days' acute suffering, registered as dead, his disease being "asthma." A doctor, glancing at the body, fancied he detected signs of life in it. A lighted taper was applied to the nose of the carbineer—a mirror was applied to his mouth; but all without success. The body was pinched and beaten, the taper was again applied, and so often and so obstinately that the nose was burned, and the patient, quivering in all his frame, drew short, spasmodic breaths—sure proofs, even to a non-professional witness, that the soldier was not altogether dead. The doctor applied other remedies, and in a short time the corpse was declared to be a living man. Luigi Vittori left the hospital to resume his duties as carbineer, but his nose—a scarred and crimson beacon on his face—told till he died (which was soon afterward) the sad story of his cure in the very jaws of the grave.

Stories are told of men who, after sentence of death at the hands of the doctors, returned to life blighted in intellect. Some of these victims of medical incapacity were men of position in society, but others—the great majority—were poor and friendless. Hospital cases have principally to do with the poor, and, in hospitals in warm countries, patients who show signs of approaching dissolution are quickly disposed of. Camillo de Lellis, the founder of an order of hospital monks, or

Brothers of Charity, speaks in his memoirs of the frequency of premature burials in Italy. "Ah, merciful God!" he exclaims piously, "how many living men and women are annually taken to their graves in this Christian country!" Camillo was of opinion that the victims might be numbered by many scores—nay, by hundreds—in the course of a single year.

One day, after visiting the beds of the sick in a certain hospital in Lombardy, of which the name has been left in blank, Camillo entered the *morgue*, and found strewed upon the floor a great number of corpses, one of which was bleeding profusely from the head. "A dead man can not bleed in this way," thought Camillo, and had the body taken to another room, and there examined. The man was alive, and but for an accident would have received burial. He had been thrown to the ground with some violence a short time previously, and, then and there receiving the wound above alluded to, recovered consciousness. But he only survived his sentence of death three days; he died of the blow which had awakened him from his trance.

But there are double deaths—twofold burials—which are perhaps the most horrible of all. Society thinks it is burying one person, but the "deceased," being a woman, may from the point of view of maternity include two lives, or even more. Gasparo Rejes tells the story of a child born in the tomb whose mother was buried alive. The lady was the wife of a man of property named Francesco Orvallos, and "died," while far advanced in pregnancy, during her husband's absence. Orvallos, returning home the day after the funeral, had the tomb opened, not because he suspected foul play, but because he wished to gaze once more on the face of his beloved. The lady was in truth dead, but death had transpired in the grave. A child, struggling into existence, met the gaze of the bereaved husband, and was removed without difficulty by a medical assistant. The mother was once more consigned to the dust, but the child lived to be a man, and, carrying till his death the name of "Fruit of the Earth," occupied for several years the post of lieutenant-general on the frontiers of Cherez. This story is reproduced by the late Professor Comi in his treatise on "Apneology." Those who doubt it have only to read the following account of what is called "Involuntary Homicide," which happened in the south of Italy (at Castel del Giudice) in November last, and of which accounts were published at the time in the Neapolitan and English papers:

A poor woman at Castel del Giudice, in the province of Molise, was taken ill with the premonitory symptoms of childbirth, and, having fainted away while the doctor was being sent for, was, on his arrival, declared dead. Burial follows death very rapidly in southern countries, especially in Italy: it is the night of the tomb setting in without the twilight of the death-chamber; and eight-and-forty hours in the north of Italy, and four-and-twenty in the south, is the time allowed by law. If the "dead" awake in that time it is well. If not, they are doomed, and no one—not even a father or a mother, a husband or a wife—can save them from the hands of the grave-digger. This was the case with the poor woman of Molise. Her friends had doubts as to one, at least, of the deaths—that of the unborn babe—but the doctor was inexorable. He refused to operate on the "corpse" to save the infant-life, and the syndic, approving of his conduct, ordered the body to be buried. The funeral took place *exactly at the twenty-fourth hour*—that is to say that the body (being a poor one) was thrown into the ground like a dog. Dog-like, too, it had no rights, for a few days afterward it was unearthed to make room for another corpse—that of a girl—which was to be thrown in over it. But the *becchini* (the grave-diggers) perceived while doing their work that the woman buried the week before "had moved in the grave." Her hands were up to her mouth; her eyes were wide open and staring frightfully—she had been trying to bite the bands by which her wrists were fastened. But the bands of her legs were rent asunder, and there, in the dust beside her, was a dead child! The woman and the babe (a boy) whom law and medical incapacity had slain were taken out of the earth to be medically examined and legally provided for, and the new corpse (was it a corpse?) was thrown in in their stead. The doctor and the syndic were arrested, and condemned to three months' imprisonment, and the mother and child were buried again with two medical certificates instead of one. The legal authorities—somewhat late in the day—wished to do everything in "proper form," and the child, born in the grave, procured for its mother a second burial.

This horrible crime—the crime of burying a woman alive and murdering an unborn babe five or six feet underground by medical sanction—could with difficulty have occurred in England. English law provides an interval of a week (more or less) between death and burial, and the seeming-dead may in a week's time return to life—that is to say, that the body, with the suspended life dormant within it, may, by chance or by medical treatment, reassume its functions, or a portion of its functions, before burial has become a legal or a sanitary necessity; but it can not be stated with certainty that all persons buried in a northern climate—such a climate, for instance, as England—are in reality dead after the delay of a week has been accorded. Hasty and sudden burials are not always a question of climate or of temperature. In times of pestilence the week's delay is in many cases, even in northern climates, reduced to a few hours; and in Italy, where the minimum interval between death and burial is a day and a night, and the maximum two days and two nights, the victims (or the supposed victims) of epidemic are buried as soon as dead—that is to say, as soon as they appear to be dead, which, in exceptional times, amounts much to the same thing. The manifest blunder is that of supposing all dead persons—i. e., all persons dying in days of pestilence—to be dead of that particular pestilence ; and the excuse for it, if excuse it be, is the desire to remove from the living all possibility of contagion from the bodies of the dead, dispensing with experiments with a view to reducing risk ; and making sure, so to speak, of the corpse without giving it the benefit of a doubt.

The fact is, that the modern inhabitants of Italy—i. e., modern Italian legislators—are extremely intolerant of what may be called the romance of the death-chamber. Reverence for the deceased, a craving for the companionship of the unburied corpse, is not encouraged in Italy. As soon as life is extinct, or is believed to be extinct, the human being ceases to be sacred. It is earth or clay and nothing more, and the glamour of a beloved face which no longer smiles does not, to an Italian mind, speak of a soul hovering near the body, a soul asleep, not dead, which haunts the chamber of woe, and makes itself felt, as it were instinctively, in the presence of the mourners. Theology teaches Italians that the soul of the deceased is in purgatory, and that the altar and not the death-bed is the place to kneel at ; so that, by kneeling and praying and doing penance(by fees and masses), mourners may be able to comfort the souls of the departed in the limbo they inhabit. Corpses belong in the first instance to the priests (who, after the unction by sacred oil, light tapers by the bedside) ; and in the second instance to the legal or sanitary authorities who employ the grave-diggers. The death-chamber is abandoned by the mourners, who flock to the church ; and the room, and sometimes the whole house, is furbished up, and even whitewashed, as if the death of a near and dear relative had brought contamination upon it.

Now, it would be interesting to discover at what period of history the Italians began to be so severe in their treatment of the dead. The ancient inhabitants of Italy were by no means so rigorous. They were tender in the death-chamber, and careful at the funeral-pyre ; though pagans, they were merciful in matters of life and death. Their burial laws were to a great extent similar to those of England—similar as regards the interval between death and funeral, and only different as regards the funeral itself.

The Romans had indeed many experiences of official and medical blundering, and that is perhaps the reason why they were, at certain periods, so careful in their funeral rites. Pliny tells the story of the Consul Acilius, who, being reputed dead, was placed on the pyre, and started up to shriek for assistance while the flames were gathering round him ; but too late to be saved. Lucius was burned alive ; and Tuberus, waking from the trance of death while preparations were being made to burn him, was removed by his friends and others from the stake. The interval between death and funeral was fixed at eight days. It was seldom less, and it was sometimes more ; for Licurgus, in his anxiety to prevent accidents—i. e., medical and judicial murders—fixed the interval at eleven days. Why do the modern Romans, and all the modern inhabitants of Italy, insist on burying their dead within forty-eight hours? Simply—say the legislators—because the climate requires it; i. e., because it would not be fair to the living to allow the dead to remain unburied for a longer space than two days and two nights. Query: was the climate of Italy under Julius Cæsar very different, in point of heat or moisture, from the climate of Italy under King Humbert?

But it has always, and in all countries, been difficult to ascertain the difference between *Todt* and *Scheintodt*—death and the semblance of death. Dr. Gandolfi, a learned Italian writer, whose work on "Forensic Medicine" * was revised by the illustrious Mittermayer, is of opinion that medical men are themselves liable to make mistakes on this important question. He says—1. That "the organic phenomena which precede apparent death can not of themselves be distinguished from those which precede real death, and that for a certain time it will be difficult to decide, scientifically, whether life be suspended, or extinct"; and, 2. That "many phenomena which announce real death are the common and necessary indications of apparent death, as for instance the want of motion, of sense, of breathing, and of pulsation."

These are terrible sentences! How many persons are denounced as dead simply because they have ceased to breathe and move and show signs of a pulse—persons who, according to Gandolfi, may not, in all cases, be ready for burial! It is Gandolfi's opinion that persons "denounced as dead" may in some rare instances be the witnesses—the mute and fear-stricken witnesses—of their own funeral; that they may know perfectly well that they are going to be put into coffins, and thence into the earth, and yet be powerless, alive as they are, to avert the catastrophe of a legal murder! The following illustration of this point is authenticated by Bruhier, and is quoted, in slightly different words, by Dr. Gandolfi:

A schoolmaster in Mohlstadt, named Wenzel, was legally denounced as dead, and got ready for burial. He was to be buried on a certain fixed day, but his sister, who lived far off, had not arrived; and it was decided that the funeral should be postponed. The "deceased," in his winding-sheet, unable to move, and apparently unable to breathe, heard with joy of this delay, and tried, but utterly in vain, to open his eyes, which were fast closed. His sister arrived, and, finding him dead, burst into a paroxysm of tears, and, seizing his hand, reproved him passionately for thus dying without one word of farewell. She took his head between her hands, and, pressing it wildly, looked at him with a fixed and half-demented scrutiny. The eyelids of the "deceased" were seen to quiver; the eyes half opened; he was saved! He had succeeded in putting his latent self in communication with the outer world; and what he himself had begun the doctors completed. Here was a man who, but for his sister's delay, would have been buried

* "Medicina Forensa Analitica," by Giovanni Gandolfi, Milan, 1863.

alive! Bruhier's story is, in fact, the confession of Wenzel. It is the story of a patient describing his horror on finding himself a dead man; and, without much confusion of terms, it might fairly be called the "Confessions of a Corpse." Dr. Gandolfi asserts that many such cases have been recorded in various parts of Europe, and that in most instances the cases have been "proved and authenticated." Gandolfi is an authority; and all persons of a quibbling or skeptical nature would do well to consider the matter thoroughly before condemning his evidence.

But it is needless to prolong the list of examples. Enough has been said to show the wickedness of hasty funerals, and the necessity of establishing a proper system of tests. But these tests, so long expected, are not forthcoming. Many physicians are, indeed, of opinion that no such system is obtainable in the present state of medical science. There are, they affirm, a great many ways of proving death, if sufficient time allowed be for experiments; but during the experiments, or before the experiments have begun, the supposed corpse may, they declare, pass from apparent to real death, and thus, without sign or warning, frustrate all inquiry. Celebrated physicians can not be at the death-beds of all sick persons. The poor, and even the rich, must oftentimes content themselves with the services of doctors who are not famous either for learning or intuition; and the medicines and appliances by which distinguished physicians might succeed in testing the existence of life, in persons suffering from trance, would, in the case of poor people, cost too much; and no one is willing to guarantee their final success. For it is important to bear this point in mind: it is one thing to certify that a "corpse" is not really dead; it is another thing to revive that corpse after the inner life—latent and slow to assert itself—has been properly recognized. No; what is wanted is a *simple* test, and not a complicated test, or a complicated series of tests, which would be out of the reach of the poor, and beyond the power of inexperienced or badly-paid doctors. Let us have that test as soon as possible! No doctor deems it an impossibility. It is a matter of difficulty, and that is all. But difficulties as great as, or greater than, this have been mastered over and over again by modern science. —*Belgravia.*

WHY DO SPRINGS AND WELLS OVERFLOW?

By JOSEPH J. SKINNER, Ph. D.

THE commonly accepted answer to the above question is that the water of springs and of flowing wells is forced out by the pressure of other water at some higher level, this pressure being transmitted to the water of the spring or well through continuous underground channels, either containing water alone or water filling the interstices of some porous material, these waters being the product of rainfall, dew, and snow. But this answer has sometimes been found not to satisfy a certain class of minds; and, as long ago as 1834, Arago thought it not beneath him to publish in the "Annuaire du Bureau des Longitudes" for 1835 a considerable essay, in which he shows conclusively that the rise and flow of water in springs and artesian wells are sufficiently explained by the cause assigned above. Further on will be found a translation of some passages from this elegant essay.

Arago was so certain of the correctness of his views, that from his knowledge of the geological formations of France he not only foretold that potable water would be found by boring an artesian well at Grenelle, near Paris, but that the water would rise and overflow the surface. In 1833 he succeeded in getting the French Government to undertake the boring of this well, and although about eight years were required to complete it and it was for some time in danger of being abandoned, his urgent representations prevailed in obtaining a further prosecution of the work, and in 1841 his foresight was rewarded with the splendid success familiar to the public. Modern engineers, in judging of the chances of getting flowing water from an artesian well in any particular locality are guided by the same general theory as that held by Arago.

But a writer in the November number of this magazine combats this theory, "not merely from speculative motives, but in the interest of public health," and offers an explanation of his own, involving a "newly discovered force" which "not only may, but which positively must, force waters out of springs at high elevations." This "new force" as it is called in another sentence, is "the resultant of the earth's centripetal and centrifugal forces," and it produces springs and flowing wells by acting "impulsively upon the subterranean water deposits," tending "to force them into and though the natural channels of the earth's crust." It is proposed here to examine Mr. Green's article in some detail, in connection with a consideration of the generally accepted theory of springs and flowing walls.

A peculiarity in one or two of Mr. Green's quotations led me to verify them in the works cited by him, and in doing so I could but notice that he had apparently made a number of slips of the pen, which, though perhaps unimportant in themselves, yet give indication of some carelessness. For instance, in quoting from "Littell's Living Age," he changes *Colne* to Coln, *Watford* to Wetford, *Pole's Hole* to Pales's Hole, *Dickenson* to Dickinson, *Canstadt* to Constadt, *Bruckman* (which should have been *Bruckmann*) to Buckmann, and *predicted* to discovered. Another of his quotations from the same source is this, "The artesian well at Tours rose with a jet that sustained a cannon." The original said, "An artesian well at Tours rose with a jet that sustained in the air a cannon-ball." As the account of

Professor Buckland's address given in "Littell's Living Age" was not a *verbatim* report, even this statement seemed to me likely enough to have suffered a slight change at the hands of the reporter ; so I went one step further back, to Professor Buckland's "Bridgewater Treatise," of which he spoke in his address, where I find this statement : "At Perpignan and Tours, M. Arago states that the water rushes up with so much force, that a cannon-ball placed in the pipe of an artesian well is violently ejected by the ascending stream." Something like this is probably what Professor Buckland said in his address ; and the difference between the ejecting of a ball from a pipe and the sustaining of it in the air may have seemed to the reporter of the address of slight consequence ; but when you go from *ejecting a ball from a pipe* to the *sustaining of it in the air*, and then to the *sustaining of a cannon*, one is reminded of the man who was said to have thrown up something as *black as a crow*, and as the story passed from mouth to mouth he was finally declared to have thrown up *three black crows*.

On page 76 of the November "Popular Science Monthly," in discussing Mr. Howell's article on the "Subterranean Outlet" to the Upper Lake region, Mr. Green says of Mr. Howell that "having shown that Lake Superior at its surface is 600 feet above the Atlantic and at its bottom 573, and Ontario to be 235 feet above, with the same depth as Superior, he proceeds to make the following significant statement." This quotation would make Lakes Superior and Ontario each only twenty-seven feet deep, which is evidently a mistake ; and on referring to Mr. Howell's article in "Scribner's Monthly" we find that he did not say that the bottom of Lake Superior is 573 above the Atlantic, but that "we find its bed descending 573 feet *below* the level of the Atlantic" ; neither did he say that Ontario has the same depth as Superior, but that it "descends to an equal distance below the level of the Atlantic."

But let us begin at the beginning of Mr. Green's article, and see how he starts off. After a few words of introduction, he quotes from the account of Professor Buckland's address a few sentences ending as follows : "At Brentford, England, there were many wells that continually overflowed their orifice, which is a few feet only above the Thames. In the London wells the water rises to a less level than in those at Brentford." Mr. Green then says : "By hydrostatic pressure, the Professor, of course, means a head, i. e., that the water flowed to these wells from a higher point. If this rise were due to hydrostatic pressure, why did the water rise to a lower level at London than at Brentford among the hills?" Now, Professor Buckland's statement, just quoted, makes the orifice of the Brentford wells "a few feet only above the Thames," and Mr. Green makes his first imaginary difficulty by placing these wells "among the hills." He then quotes largely from Professor Buckland's address, and afterward exclaims : "Wells to supply London, the Professor thinks, must not be utilized to draw water from a depth of thirty or forty feet, because it would cut off the supply due to the rains which do not sink deeper than three feet!" But the Professor had not said that "rains do not sink deeper than three feet." He had, indeed, said that one intelligent manufacturer, Mr. Dickenson, had found by a rain-gauge that "except in *December*, *January*, and *February*, rain-water rarely descends more than three feet below the soil," etc. This statement apparently convinces Mr. Green that rain-waters *never* get deeper into the earth than three feet. But there are soils and soils.* And Professor Buckland did not neglect to point out their differences. He said, "The rain that falls on the uncovered *chalk* within the area of these basins (like that of London) descends, by countless crevices, into the *lower regions of the chalk strata*," etc. And even Mr. Dickenson's observations *during many years* had shown him that, in spite of the fact that in the drier part of the year the rain-waters rarely sank into his *soil* more than three feet, yet the quantity of summer water in the river Colne varied with the rain in the preceding winter. He probably knew, therefore, that these winter rains must be largely absorbed by the sponge-like chalk formations in the neighborhood, and slowly work their way downward many feet, to issue gradually at lower points in the form of springs to feed the river in summer.

Mr. Green quotes further from Professor Buckland's address, showing the great value of artesian wells in Wurtemberg, and then goes on: "From which quotations it appears that the Professor is in a remarkable position. At Wetford" (*sic*) "these wells could not be utilized because the river-supply of the Coln" (*sic*) "would be exhausted; but in Germany they were a new and important source of supply to the rivers themselves." The Professor's position may be remarkable, but it is certainly reasonable. For it is a well-known fact that in some localities, that of Tours for one, as stated by Arago, artesian wells may be bored to any number hitherto tried without sensibly affecting the flow of those first sunk in the immediate neighborhood, while in other localities every new well either diminishes the flow of old wells or makes the level of the water in them sink. This last is the case near London. The "American Cyclopædia," article "Artesian Wells," says: "In the vicinity of London it is observed that the height to which the water rises diminishes as the number of wells is increased. In 1838 the supply of water from them was estimated at six million gallons daily, and in 1851 at nearly double the amount, and the average annual fall of the height of the water is about two feet." Professor Buckland had also stated that "Mr. Clutterbuck demonstrated, by a long-continued series of measurements of the water in the chalk-hills of Hertfordshire, near Watford, that every drop of water taken from that neighborhood would have been ab-

* Arago said—but he apparently lived too early—"Every one knows that in many places the upper ground is of sand, and that sand lets water through it like a sieve.

stracted from the summer and autumn supplies of the river Colne." Hence, even if the wells in Germany were, as stated rather strongly by Mr. Green, "a new and important source of supply to the rivers themselves," it would not alter the fact, shown by experiment, that the proprietors of mills on the river Colne, and the owners of adjacent water-meadows, would have been robbed of rights which they had inherited from time immemorial, by drawing the water-supply of the great city of London from wells in the chalk formations of Hertfordshire.

But Mr. Green's two propositions that differ most essentially from the commonly accepted theory of artesian wells are—1. That the flow of water from them is not due to pressure transmitted from water at a higher level, but to "some force not yet identified"; and, 2. That the supply of water for such wells, and indeed for ordinary springs, comes from "subterranean waters, seldom if ever influenced by rains" (p. 75, line one). Mr. Green identifies the required force as "the resultant of the earth's centripetal and centrifugal forces," and, having found that the tendency of this resultant is to force water *up*, wherever there is an opening upward in the earth's crust, of course it is necessary to suppose that there is a plenty of subterranean water already down. He seems to think it entirely unnecessary to suggest any means of replenishing the supply of this subterranean water, or even to imagine that it could ever need replenishing.

Listen to Mr. Green: "Imagine the 'majestic column' at Grenelle rising thirty feet high, and the overflow in the other cases being due to hydrostatic pressure—i. e., due to the fact that all these immense floods were the result of a flow from some other higher bodies of water." Ordinary people will find it as easy to imagine this as to suppose that these floods are the result of flow from *lower* bodies of water unconnected with higher ones. But he goes on: "Why did it not occur to Professor Buckland that, however high and abundant the source, such drains must of necessity have sooner or later exhausted the supply, if no equivalent streams were flowing into that also? But suppose this" (*sic*) "to be so, whence could come the higher head to flow into and supply that in turn? Carry this on until a flow is secured from the highest land on the earth, and then whence comes the flow to supply that?" This is beautiful. Why did it not occur to Mr. Green that, however *low* and abundant the source, such drains must of necessity have sooner or later exhausted the supply if no equivalent streams were flowing into that also? But suppose this to be so, whence could come the *lower* head to flow into and supply that in turn? Carry this on until a flow is secured from the *center of the earth*, and then where are you?

In another place (p. 81) Mr. Green says: "Suppose it had been *fully proved* that a particular overflowing spring was caused by hydrostatic pressure, it would still remain to be accounted for how the water got to that higher point. This can best be done by the force demonstrated," etc. But supposing, if you can suppose, that a particular overflowing spring were caused by Mr. Green's "newly discovered force" acting on a lower body of water, it would still be for him to show how, according to his theory, the water got to that lower point. His position plainly is (see p. 81), that if any openings exist between bodies of water imprisoned in the earth's crust and the surface of the earth, these waters, unless entirely isolated bodies, would as a rule flow upward. If there were millions of cubic miles of water in accessible subterranean reservoirs, and no drain on them but that caused by the wells made by man, the supply might be considered "ample for all practical purposes," no matter how it got there or what forced the water up; but Mr. Green argues that not only flowing springs but the bulk of the waters of the rivers St. Lawrence, "Ganges, Nile, Indus, Senegal, Rhine, Rhône, Vistula, Elbe, Loire, Gaudiana, Po, Adige, Swale, Tay, Severn, Don, Monongahela, Platte, Missouri, and numerous others" must be derived from a subterranean water-supply, which, he says (p. 77), "is known to be constant, and has always been so." One would think that rivers like those mentioned, flowing for centuries, if fed by a *subterranean water-supply*, would ultimately make a serious drain on the subterranean reservoirs; but, although Mr. Green's theory does not admit the possibility of any water getting back into these reservoirs, rivers and wells still flow.

After giving Professor Buckland's illustration of the theory of artesian wells, in which he likens the case in nature to a layer of sand and water between two saucers, Mr. Green says, "Should these exceptional and assumed conditions occur in nature, the result would be substantially as indicated." But we know that similar conditions do occur, and not very rarely either. He continues, "But, as will be seen at a glance, the flow from a well sunk under such circumstances would be limited to the amount of water between the two saucers, and this will be limited to the quantity of rainfall." This is very true. He adds, "Since flowing wells and springs are seldom if ever thus limited, we infer that the case supposed does not occur." On the contrary, we have every reason to believe that flowing wells and springs are almost always thus limited. Mr. Dickenson's observations, already quoted by Mr. Green, proved that the quantity of summer water in the river Colne varied with the rain in the preceding winter. In every particularly dry summer springs by the thousand are entirely dried up, and the flow from the majority of others is greatly diminished. On the other hand, in wet seasons all but the most extraordinary springs have their flow increased. In some geological formations increase of flow occurs very soon after the beginning of rains. Arago states as the uniform observation of miners, especially those of Cornwall, that in mines situated in the midst of certain limestones water increases in the deepest drifts a *very few hours* after it has begun to rain on the surface of the earth. He also refers to springs on the coast which gush out from vertical cliffs of chalky limestone, which in the same way increase largely in strength immediately after rain.

That artesian wells are not sensibly affected by particular rain-storms is no proof that they are not ultimately supplied by rains, but only shows that the quantity of water furnished by the wells is exceedingly small compared with the total quantity at any time in the layer of porous material tapped by the wells. Such layers, between two saucer-like formations of impermeable matter, would generally have some points of their outcrop at a lower level than others. At these low points of the outcrop natural springs would occur, which would have a flow more or less constant in proportion to the extent and height of the porous layer above them, and their flowing would continually tend to draw the level of the water in the porous layer down to their own altitude. Rains, falling on the exposed edges of the porous layer, would in great part be absorbed, and, gradually trickling through the pores, be slowly discharged by these natural springs. If an artesian well had its opening into the porous layer far below the lowest of these natural outlets, no ordinary rain would sensibly change the effective head of water that supplied it; but, if rains should cease entirely, the springs and the well would ultimately stop flowing. In a work on "Water-Supply Engineering," which contains much valuable information, Mr. J. T. Fanning says of such a geological formation as the common theory of artesian wells assumes, that when first discovered it "is invariably full to its lip or point of overflow. Its extent may be comparatively large, and its watershed comparatively small, yet it will be full, and many centuries may have elapsed since it was molded and first began to store the precious showers of heaven. A few drops accumulated from each of the thousand showers of each decade may have filled it to its brim many generations since; yet this is no evidence that it is inexhaustible. If the perennial draught exceeds the amount the storms give to its replenishment, it will surely cease, in time, to yield the surplus." (Compare with this the extract given above from "The American Cyclopædia," showing an annual sinking of two feet in the level of the water in the artesian wells near London.)

Mr. Green can not account for the flow of streams from the mountain-region of Pennsylvania and from Lake Chautauqua without the intervention of his "newly discovered force." He quotes approvingly a statement that "it is a wonder to the unpracticed observer where the water-supply of Chautauqua Lake comes from." "Unpracticed observer," indeed! But the practiced observer will tell you without hesitation that the water-supply comes from the clouds. Mr. Fanning (*op. cit.*) states, as the estimate from experiments, that "in the Eastern and Middle United States the evaporation from storage reservoirs, having an average depth of at least ten feet, will rarely exceed sixty per cent. of the rainfall upon their surface." It follows that any natural exposed basin, under these circumstances, would surely fill up, just from the rains on its surface, if there were not some outlet for the water. Mr. Fanning gives the mean annual rainfall at Fredonia, New York, a few miles from Lake Chautauqua, as 36·55 inches. If we assume that the lake has an area of forty square miles, and take the annual rainfall on its surface at three feet in depth, the total volume of this rainfall would be 3,345,408,000 cubic feet. Supposing that sixty per cent. of this is lost by evaporation, there will yet remain in average years 1,338,163,200 cubic feet of water to be somehow disposed of, which is more than would supply a stream eight feet wide and one foot deep, running for a year at the rate of three and a half miles per hour. Besides the rain falling directly on the surface of the lake, a calculation of the area of the land around it, at a higher elevation than its water-level, would undoubtedly show, no matter what unpracticed observers might anticipate, that the rain-water known to fall on this area would be ample to supply all the springs that flow into the lake, and leave a good margin of surplus to evaporate from plants and soil, and to filter away into the earth.

It seems as if Mr. Green must be somewhat imaginative when he says that, "from the highest mountains in the world—the Himalayas —*out of their highest points*, great cataracts and streams have poured and still do pour," etc. Has any man ever been anywhere near the highest points of the Himalayas to verify such a statement? I translate the following from Arago's work already mentioned:

"The argument chiefly depended upon by those who felt obliged to seek the origin of subterranean waters in the precipitation which intensely hot aqueous vapors, coming from central regions, had experienced at the moment of their contact with the cold, earthy layers near the surface, was drawn from a fact well worthy of examination: I mean the pretended existence of tolerably abundant springs *at the summit*, at the culminating point, of some mountains. Our little *Montmartre* itself figured in this polemic. There was, indeed, upon this hillock, a spring (perhaps it still exists) which was hardly sixteen metres (fifty feet) below its highest part. No water, it was said, could constantly feed a spring thus placed, without coming from beneath in the state of vapor. Upon examination, however, it was found that the portion of Montmartre above the spring, and which could consequently transmit its waters by the method of simple interior draining, was about five hundred and eighty-five metres long and one hundred and ninety-five metres wide. Now, the mean volume of rain which falls in Paris upon such an extent of ground, between the 1st of January and the 31st of December, much exceeds the quantity of water which the little spring in question annually yielded.

"It was necessary, then, to seek for the difficulty at another point.

"This was believed to have been found in a locality not far from Dijon; but there as well, in spite of appearances, the rain-waters received on the portion of land overlooking the spring could amply suffice for its supply."

After referring to the former ignorance of people concerning the quantity of rain, of dew, and of snow, falling in different regions, Arago continues: "For example, people did not believe that the basin of the Seine . . . . received annually by rain a quantity of water equal to the tribute which the Seine bears to the sea in the same space of time. Perrault and Mariotte first studied the question *experimentally*, and they found, as is usual in such cases, that the vague conceptions of their predecessors were precisely the opposite of the truth. . . . The volume of water which passes yearly under the bridges of Paris is hardly the third of that which falls in rain into the basin of the Seine. Two thirds of that rain either return into the atmosphere by evaporation, or sustain vegetation and the life of animals, or drain into the sea by subterranean passages."

Without insisting further on the fact that the rain-waters, dews, and snows falling on higher grounds must be sufficient to account for all flowing springs and wells (except, possibly, such cases as the geysers), let us see how Mr. Green's subterranean water-deposits are to be driven to the surface of the earth by his "newly discovered force." Why, by making the earth's centrifugal force act in the direction of the *tangent* to the earth's surface, and then getting the resultant of this force and of gravity! Further, since the question of the relative intensities of these two forces "does not enter into the problem," you may assume that they are equal, and thus you will find that "the direction of the resultant itself is, say, 45° from the direction of the force of gravity. . . . Moreover, since the resultant has been shown" (by saying that the diagonal either of a square or of a *parallelogram* is longer than either of its sides) "to be greater under all circumstances than gravity, certainly the vast aggregations must also be greater than the aggregated gravity, and will be able to overcome it under the conditions stated. . . . The intensity of the centrifugal force will increase with the distance from the center of the earth, while gravity will decrease; the *resultant will also increase.* Thus we find the strongest and most abundant overflows at the tops of mountains or on high plateaus."

As a specimen of mechanical exposition this is almost unique,* but it is too ludicrous to mislead. In point of fact, as every schoolboy ought to know, the centrifugal force due to the earth's rotation, on a particle at any place on the earth, does not act in the direction of the tangent

* Mr. Green is not quite the first writer who, in undertaking to overthrow a well-established mechanical explanation of natural phenomena, has assumed that the earth's centrifugal force acts in the direction of the tangent to its surface. (See discussions on "The Tides," in vols. xi. and xii. of this magazine.)

to the earth's surface, but in the outward direction of the radius of the circle of latitude of the place; a diagonal of a *parallelogram* is frequently shorter than either of its sides; the centrifugal force acting on a particle, due to the rotation of the earth, is never more than about the $\frac{1}{289}$ part of the force of gravity; the direction of the resultant of this centrifugal force and of gravity is always very nearly that of gravity; the intensity of this resultant is always less than that of gravity; and instead of increasing with the distance from the center of the earth it decreases. Perhaps these are points that make no difference in the value of Mr. Green's theory; but still they are worth the consideration of any one who proposes by contraries to upset the doctrines of such men as Arago, Faraday, Garnier, and Halley.

Not even the wonderful fact mentioned by Mr. Green, that "by inclosing an overflowing spring tightly, and allowing the inclosure to be terminated by a tube with an opening carried to a level below the fountain, the flow was increased"—not even this will overthrow the principles of mechanics, as any one who ever understood a siphon would know. Mr. Green says, "the flow was increased because the channel was increased, and the resultant of the natural forces with it." But if the resultant increases with the distance from the center of the earth, then why could he not increase the flow still more by running the tube to a great height above the fountain instead of below it? But even Mr. Green would hardly expect to increase the flow by such means. For it is well known that by confining the water of an artesian well to a tube in which it must rise above the ground, the natural flow is rapidly diminished as the height of the tube increases. The "American Cyclopædia" says: "The flow from this well (at Passy, two miles from Grenelle) began slowly, but on September 27th (three days after striking the water) had reached over 5,500,000 gallons per day. The yield at the mouth was greatly decreased when raised through a tube twenty-five feet high; a like result followed at Grenelle, where the yield was 440 gallons per minute at the surface, but decreased to 135 gallons when forced through a tube thirty-three feet high." Mr. Green will have to charge this great decrease of flow to something besides increase of *friction*; for it is easy to see that, if the tube were extended up just to the point to which the water would rise without flowing out, there would then be *no* friction. In fact, the laws of hydraulics and hydrostatics have something to do with the subject of artesian wells.

I have already mentioned some inaccuracies of statement in Mr. Green's discussion of Mr. Howell's article in "Scribner's Magazine." Mr. Green, finding that the difference of level between the surfaces of the water in Lakes Superior and Ontario is three hundred and sixty-five feet, becomes certain that there can be no subterranean water-connection between these lakes; for, he says, "If this channel exists as supposed, the surfaces of these lakes would find a common level, instead of a difference of three hundred and sixty-five feet"! Here is where Mr. Green should have brought in his ideas on friction, and have studied Professor Buckland's address more closely. In that address it is stated that "the surface-line of any subterranean sheet of water may be ascertained by measuring a series of wells at distant intervals along the dip of the stratum under examination. . . . Mr. Clutterbuck had further observed that the surface-line of subterranean sheets of water was not horizontal, like the surface of a lake, but inclined at a rate varying from fourteen to twenty feet per mile, in consequence of friction caused by the particles of the strata through which those sheets of rain-water descended with retarded motion to be discharged by springs. This inclination of the subterranean water-line in the chalk of Hertfordshire had been found, by Mr. Clutterbuck, to be nearly at the rate of twenty feet per mile in the chalk between Sir John Sebright's park at Beechwood and the town of Watford; and fourteen feet per mile in the chalk under tertiary strata in some parts of the basin of London. The engineers of the Southampton Railway had found a similar fall of about sixteen or seventeen feet per mile in the wells at the railway-stations between Basingstoke and Southampton." Without expressing an opinion of my own as to whether there really is or is not a subterranean water-channel between Lakes Superior and Ontario, it is evident enough that, even if there is, its size and character, as being more or less obstructed by solid or porous materials, together with its length, would have *some* influence in determining the quantity of water which could flow through it, even with a difference of water-level over its extremities equal to three hundred and sixty-five feet. Unless, therefore, Mr. Green's "newly discovered force" should suddenly cease to make Lake Superior an "overflowing spring of subterranean water," or, rather, unless the region from which Lake Superior gets its water should be deprived of its yearly rains, we need not immediately look for a common level of the water in Lakes Superior and Ontario.

CORRESPONDENCE.

"WASTED FORCES."

Messrs. Editors.

A RECENT issue of your "Monthly" contained a criticism, by Mr. J. W. Cloud, of some points in my paper on "Wasted Forces" published in yours of July, in which it is alleged I am in error. I had intended replying at once to this criticism, but have been prevented until now by circumstances. My critic makes the point that, in my attempt to account for the low duty of the steam-engine, I have ignored one of the chief elements of the problem, namely, "the low efficiency of the medium."

To this criticism I beg to reply that for the purpose of showing the margin for possible improvement in engines, whether deriving their motive power from steam or any other medium, the only elements entering into the problem are those I have named in my article, to wit: 1. The amount of work that should be given out, and which is the equivalent of the number of heat-units imparted to the medium by the combustion of the fuel; and, 2. The amount of work actually realized. The difference is the loss, and this loss is due *not* to "the low efficiency of the medium," but to the low efficiency of the machine.

To make myself quite plain, I will add my understanding of what a perfect engine should be. The perfect engine, hypothetically stated, is an apparatus that will utilize all the heat-units evolved by the complete combustion of fuel in the generator in the generation of steam; that will use all the steam that the generator supplies, converting it into water in so doing; that will put that water back again into the generator whence it came; and that will give out during a given time an amount of work that shall be the equivalent of the number of heat-units that have disappeared during that time.

I confess my inability to perceive what the question of latent or sensible heat has to do with the problem; and, in view of the fact that my critic has taken the pains to warn the readers of the "Monthly" that my statements might give false impressions, I wish to reaffirm the strict correctness of the theoretical view I have advanced; and to assert, my critic to the contrary notwithstanding, that the difficulties in the way of increasing the duty of the steam-engine to a very close approximation to that which theory calls for are *purely of a mechanical nature, and therefore not beyond the power of mechanical science to overcome.*

This is the gist of the matter, and I take direct issue with my critic in denying that the element of the high latent as compared with the low sensible heat of the medium, whether it be steam or any other, that is used, is the impassable barrier to future improvement that he would make it appear.

On another point that my critic makes, namely, that I throw too much of the responsibility of the low duty of the steam-engine on the generator, I have no hesitation, after further inquiry into the subject, to yield to him, and to admit that fifty per cent. would have been nearer the truth than twenty-five per cent., which I gave in my paper. I gave that figure simply as an opinion derived from a practice that is exceedingly variable and complex, and therefore liable to wide differences of result.

Very truly,

William H. Wahl.

EDITOR'S TABLE.

RECEPTION OF THE "DATA OF ETHICS."

THE science of morals is as legitimate as the science of rocks, and far more important. When, therefore, a new step has been taken in its development and exposition, we are interested in all the indications of its recognition. The reception of Spencer's "Data of Ethics" shows on the whole a very marked progress of religious liberality. There is much protest but large concession, while the expressions of intelligent appreciation and cordial sympathy are many and emphatic. We give some illustrations, with comments, of the manner in which his position is now regarded.

We certainly never expected to live

long enough to see the name of Herbert Spencer received with applause in a great religious convention of orthodox people; but, if the report of the London "Times" can be trusted, this extraordinary phenomenon has actually occurred. That paper of October 10th contains a report of the Church Congress held this year at Swansea, and presided over by the Bishop of St. Davids, in which the question of "Internal Church Unity" came up for discussion. The Reverend Professor Pritchard gave an eloquent and powerful address on the "Religious Benefits from Recent Science and Research," in which the doctrine of evolution was assumed as true, and as in entire harmony with all essential religious truth. He was followed by the Reverend Professor Watkins, of St. Augustine College, Canterbury, who spoke on the same subject. He said: "The currents of higher religious thought in England were being influenced by two main forces; one was the theory of evolution, the other comparative theology, or the so-called science of religion itself. The theory of evolution came to them with much of the charm of novelty, and commended itself as emphatically of British growth. It was probable, indeed, that this induction of inductions was but a step to higher inductions. Still he felt sure that, when the history of this century came to be written from the standpoint of the future, the name of Herbert Spencer would be found in the very first rank among English thinkers. [Cheers.] In ultimate principles he differed from Spencer *toto cœlo*, but he was therefore the more anxious to acknowledge the greatness of his work, and the philosophical spirit in which it had been conducted. [Hear, hear!]"

It is a common remark that all transitions of belief are painful, and none know better than intelligent missionaries how painful are transitions of religious belief. It matters little that the change is from a lower to a higher faith; violence is done to long-cherished ideas, and there is a sense of bereavement whatever the superiority of the new creed. Those, therefore, who are in the habit of having their morality garnished with theology and are accustomed to mix these conceptions and their terminology, will naturally shrink from the attempt to separate the ethics and treat it merely as an independent system of scientific principles. Such devout people will naturally look upon the "Data of Ethics" as a cheerless book. They yearn for the blessed words that have become polarized by long and sacred association. The reviewer in "Harper's Monthly," after giving a very fair account of the work, closes by expressing this idea as follows: "The treatise is a model of condensed and lucid statement, and of subtile reasoning, but the reader will be struck by the inexpressible dreariness of its tone, as if its author had verified in his own experience the simile of one of our greatest living poets, that 'the setting of a great hope is like the setting of the sun—the brightness of our life is gone.'"

It is possible that the writer believed what he here says, but it is more probable, we must say, that he was merely writing with the delicate caution thought necessary under the circumstances. The penalty of a "hundred thousand circulation" is that writers must be solicitous to *reflect* public sentiment rather than to *lead* it, and the practical result is that they generally *follow* it afar off. Our whole nation is ahead of this sentimental craving to keep things mixed which ought to be separated. We have separated the Church from the state, with great distress to many, no doubt, but with the most wholesome consequences. We have secularized our public instruction, and, although there are still many who bemoan the inexpressible dreariness of our godless education, the good sense of the country has long since ceased to heed the ecclesiastical lamentations over our policy. The disentangling of ethics from theology and the treatment of it as an independent science were demanded as a logical requirement of our educational system, for morals must be taught in public schools, while religion is left to the special agencies of spiritual instruction. And, if the country has thus decreed the divorce, why mourn over a book which merely conforms to it, and which furnishes the best defense of the national wisdom in making the divorce?

But the characterization of Spencer's work as dreary and the suggestion about "the setting of a great hope" are untruthful, and are probably morbid subjective illusions of the writer. The "Data of Ethics," so far from being a dreary book in its spirit and tone, is, on the contrary, a book more buoyant with hope and more full of rational encouragement than any former philosophical treatise upon morals ever written. It connects the moral duty and improvement of man with pleasure and happiness more closely and profoundly than any other ethical system hitherto promulgated. It arrays the grand results of modern science against a spurious metaphysics to stem the black tide of advancing pessimism; and it appeals to the unfolding of the universe as giving trust of something brighter and better for man—yet to be realized this side of his chances of perdition. Other reviewers of "The Data of Ethics" have not failed to recognize and to declare this quality of the book.

A writer in the "Home Journal" of November 16th closes an interesting account of Spencer's work as follows: "To whatever criticism the system of ethics which is thus logically developed from the law of evolution may be subjected on the part of the opponents of the evolution theory, yet this at least is evident—that as an instrument for the acceleration of the progress of society toward the beautiful ideal which it sketches out, as a stimulus to individual exertion in furtherance of this high aim, the new system is immeasurably superior to all antecedent theories of life. While other systems have encouraged the hope, none have supplied the data of a rational faith in the ultimate realization of a lofty morality among the masses of mankind. Nay, the prevalent codes which claim for themselves a supernatural origin make it their duty to proclaim the native impotency of man, and place the realization of their ideal quite beyond this 'vale of tears.'

"Believe in the perfectibility of men, believe that society in the very conditions of its existence is impregnated with the potency that insures this perfectibility, and a great step is made toward the end desired. Faith in this preëstablished destiny—the faith that the laws of the universe are working in and through and side by side with the aspirations and endeavors of individual men, can not fail but impart a new impulse to these aspirations and a new vigor to these endeavors."

Equally to the point are the words of a critic in "The Nonconformist" of November 5th—a journal which is the leading organ of English orthodox Dissenters. After an excellent analysis of the work, the writer remarks: "The value of the discussion in this volume is the glimpses it affords into the future which its author anticipates. No loftier view, we venture to think, was ever entertained. Whatever may be the opinions we hold respecting the origin of our ideas of right and wrong, and of the sanctions by which they are enforced, we can not refrain from admiring the optimism of Mr. Herbert Spencer. It is as pure and sublime as that of the most spiritual seers of the past, and it involves as radical a change in human nature as that demanded by the New Testament. It is, in his own words, 'a rationalized version of its ethical principles.' He feels, as we feel in reading his works, that his conclusions will not meet with any considerable acceptance. The fact that they are Christian in their essence is rather a hindrance to their acceptance, since conventional Christianity practically repudiates the ideal morality of its founder."

The presidents of colleges have found themselves called upon to define their position in regard to the "Data of Ethics," and their outgivings, though somewhat discordant, are none the less instructive.

It is now nearly ten years since President Porter, of Yale, in a little book on "Man," said in relation to Herbert Spencer: "No well-read student of philosophy can hesitate to believe that, notwithstanding the zeal of his admirers, he will cease to be the wonder of the hour; that as soon as the secret of his plausibility is exposed he will suffer a more complete neglect than he will fairly deserve." These were ominous words, and coming from such a source they led many to expect that very soon some powerful hand would strip the mask from a pretender and consign him to speedy oblivion. Meantime, the lugubrious prophecy remained unfulfilled. Dr. Porter, however, continues to be of the same mind, and after this long time he comes forward and with unseemly malediction again foretells the unmasking of this pretentious writer, whom he elsewhere likens to a "dexterous juggler." Yet, instead of collapsing and vanishing in accordance with this portentous Porterian programme, Spencer emerges in a new field into which the President of Yale finds it necessary to follow him with a six-columned article in "The Independent." Some pleasant things are said of the "Data of Ethics" and its author, but Mr. Spencer is sharply indicted for not making enough of the metaphysical notion of personality. Dr. Porter declares: "Indeed, personality is a conception which is utterly foreign to any and every part of his theory, as it logically should be. This grand and damning defect will one day be discovered and confessed when the factitious glamour which now invests it is dispelled."

Theologians have ever been free in the application of damnatory expletives to scientific ideas which do not conform to their standards, and the President is here merely conforming to the long-prevalent custom of his party. But, so long as these execrable defects of Spencer's theories are yet spoken of as things to be "one day discovered," would it not be well to pretermit this little game of sinister augury, and be content to curse defects already discovered?

The President of the College of New Jersey has also paid his respects to the "Data of Ethics" in the "Princeton Review," but he is at wide disagreement with his brother of Yale. In fact, they are squarely antagonistic in their estimates of Spencer, past, present, and future. Dr. McCosh does not think that he is either a sham to be exposed, or a thinker to be soon forgotten. He opens his article by saying: "Herbert Spencer commands our respect by his terrible earnestness. He has an end to live for, and he lives for it. For it he has given up professional pursuits and profits (he was an engineer), and for many years immediate fame and popularity. For at least thirty years a grand system of speculative physics founded on the recent discoveries in biology has been developing in his brain, and he must unfold it and give it forth in spite of obstacles, with or without encouragement from surroundings in the world. He is to a large extent the author, and is certainly the organizer and the very embodiment, personification, and expression of development." Again Dr. McCosh says: "What may be the estimate of his philosophy at the end of this century I will not take upon myself to predict. As embracing so many established facts, I believe there is much in his system which will abide; and I adhere to the opinion that 'his bold generalizations are always instructive, and that some of them may in the end be established as the profoundest laws of the knowable universe.'"*

That eminent logician and mathematician, Professor J. Stanley Jevons, has been recently reviewing the philosophy of J. S. Mill in a series of articles in the "Contemporary Review." In the November number he takes up Mill's "Utilitarianism," and considers his contributions to the subject of morality in relation to the present state of knowledge. He recognizes that Mill belonged to a past dispensation, and was incompetent to deal scientifically with those great moral problems by the handling of which Herbert Spencer has made a new epoch in philosophic thought. We give some of the closing passages of his article:

Such are the intricacies and wide extent of ethical questions, that it is not practicable to pursue the analysis of Mill's doctrine in at all a full manner. We can not detect the fallacious reasoning with the same precision as in matters of geometric and logical science. This analysis is the less needful, too, because, since Mill's essays appeared, moral philosophy has undergone a revolution. I do not so much allude to the reform effected by Mr. Sidgwick's "Methods of Ethics," though that is a great one, introducing as it does a precision of thought and nomenclature which was previously wanting. I allude, of course, to the establishment of the Spencerian theory of morals, which has made a new era in philosophy. Mill has been singularly unfortunate from this point of view. He might be defined as the last great philosophic writer conspicuous for his ignorance of the principles of evolution. . . . The whole tone of Mill's moral and political writings is totally opposed to the teaching of Darwin and Spencer, Tylor and Maine. Mill's idea of human nature was that we came into the world like lumps of soft clay, to be shaped by the accidents of life, or the care of those who educate us. Austin insisted on the evidence which history and daily experience afford of "the extraordinary pliability of human nature," and Mill borrowed the phrase from him. No phrase could better express the misapprehensions of human nature which, it is to be hoped, will cease for ever with the last generation of writers. Human nature is one of the last things which can be called "pliable." Granite rocks can be more easily molded than the poor savages that hide among them. We are all of us full of deep springs of unconquerable character, which education may in some degree soften or develop, but can neither create nor destroy. The mind can be shaped about as much as the body; it may be starved into feebleness, or fed and exercised into vigor and fullness; but we start always with inherent hereditary powers of growth. The non-recognition of this fact is the great defect in the moral system of Bentham. The great Jeremy was accustomed to make short work with the things which he did not understand, and it is thus he disposes of "the pretended system" of a moral sense: "One man says he has a thing made on purpose to tell him what is right and what is wrong, and that it is called a *moral sense*; and then he goes to his work at his ease, and says such a thing is right and such a thing is wrong. Why? Because my moral sense tells me it is." Bentham then bluntly ignored the validity of innate feelings, but this omission, though a great defect, did not much diminish the value of his analysis of the good and bad effects of actions. Mill discarded the admirable Benthamist analysis, but failed to introduce the true evolutionist principles; thus he falls between the two. It is to Herbert Spencer we must look for a more truthful philosophy of morals than was possible before his time.

The publication of the first part of his principles of morality, under the title "The Data of Ethics," gives us, in a definite form, and in his form, what we could previously only infer from the general course of his philosophy and from his brief letter on utilitarianism addressed to Mill. Although but fragments, these writings enable us to see that a definite step has been made in a matter debated since the dawn of intellect. The moral sense doctrine, so rudely treated by Bentham, is no longer incapable of reconciliation with the greatest happiness principle, only it now becomes a moving and developable moral sense. An absolute and unalterable moral standard was opposed to the palpable fact that customs and feelings differ widely, and Paley, on this ground, was in-

* This estimate Dr. McCosh had the sagacity to make and the courage to express many years ago in his "Intuitions of Mind."

duced to reject it. Now, we perceive that we all have a moral sense; but the moral sense of one individual, and still more of one race, may differ from that of another individual or race. Each is more or less fitted to its circumstances, and the best is ascertained by *eventual success.*

At the tail end of an article it is, of course, impossible to discuss the grounds or results of the Spencerian philosophy. To me it presents itself, in its main features, as unquestionably true; indeed, it is already difficult to look back and imagine how philosophers could have denied of the human mind and actions what is so obviously true of the animal races generally. As a reaction from the old views about innate ideas, the philosophers of the eighteenth century wished to believe that the human mind was a kind of *tabula rasa*, or *carte blanche*, upon which education could impress any character. But, if so, why not harness the lion, and teach the sheep to drive away the wolf? If the moral, not to speak of the physical characteristics of the lower animals, are so distinct, why should there not be moral and mental differences among ourselves, descending, as we obviously do, from different stocks with different physical characteristics? . . . . Many persons may be inclined to like the philosophy of Spencer no better than that of Mill. But, if the one be true and the other false, liking and disliking have no place in the matter. There may be many things which we can not possibly like; but, if they are, they are. It is possible that the principles of evolution, as expounded by Mr. Herbert Spencer, may seem as wanting in "geniality" as the formulas of Bentham. . . . Nevertheless, I fully believe that all which is sinister and ungenial in the philosophy of evolution is either the expression of unquestionable facts, or else it is the outcome of misinterpretation. It is impossible to see how Mr. Spencer, any more than other people, can explain away the existence of pain and evil. Nobody has done this; perhaps nobody ever shall do it; certainly systems of theology will not do it. A true philosopher will not expect to solve everything. But, if we admit the potent fact that pain exists, let us observe also the tendency which Spencer and Darwin establish toward its *minimization*. Evolution is a striving ever toward the better and the happier. There may be also infinite powers against us, but at least there is a deep-built scheme working toward goodness and happiness. So profound and widespread is this confederacy of the powers of good, that no failure, and no series of failures, can disconcert it. Let mankind be thrown back a hundred times, and a hundred times the better tendencies of evolution will reassert themselves. Paley pointed out how many beautiful contrivances there are in the human form tending to our benefit. Spencer has pointed out that the universe is one deep-laid framework for the production of such beneficent contrivances. Paley called upon us to admire such exquisite inventions as a hand or an eye; Spencer calls upon us to admire a machine which is the most comprehensive of all machines, because it is ever engaged in inventing beneficial inventions *ad infinitum*. Such, at least, is my way of regarding his philosophy.

Darwin, indeed, cautions us against supposing that natural selection always leads toward the production of higher and happier types of life. Retrogression may result as well as progression. But I apprehend that retrogression can only occur where the environment of a living species is altered to its detriment. Mankind degenerates when forced, like the Esquimaux, to inhabit the Arctic regions. Still in retrograding, in a sense, the being becomes more suited to its circumstances — more capable, therefore, of happiness. The inventing machine of evolution would be working badly if it worked otherwise. But, however this may be, we must accept the philosophy if it be true, and, for my part, I do so without reluctance.

According to Mill, we are little, self-dependent gods, fighting with a malignant and murderous power called Nature, sure, one would think, to be worsted in the struggle. According to Spencer, as I venture to interpret his theory, we are the latest manifestation of an all-prevailing tendency toward the good, the happy. Creation is not yet concluded, and there is no one of us who may not become conscious in his heart that he is no automaton, no mere lump of protoplasm, but the creature of a Creator.

RAILROAD CASUALTIES.

Our half century's experience with railroads is full of various instruction. Charles Francis Adams, Jr., has occupied himself with the lessons of railroad casualties. He has investigated them officially in Massachusetts, and studied them elsewhere, and he has made a little volume which he modestly calls

"Notes on Railway Accidents," but which is the first digest of information we have regarding great railway disasters, their causes, and the progress of security in this mode of travel. The book is interesting and valuable, no less for its reflections and conclusions than for its well-collated facts.

Mr. Adams begins by calling attention to the melancholy fact that there are few things of which nature or man is more lavish and careless than human life. There is really but little care about the waste of life so long as the fatality is unobtrusive. The destruction of life by war is as nothing to that by intemperance, bad sewerage, and worse ventilation; but, as it does not come by crush and shock, it attracts small attention. Railroad "horrors" make a strong impression upon the public mind; and each fresh catastrophe, by arousing public opinion, by inciting the courts to hold the companies to a more rigorous responsibility, and, above all, by the damage and detriment they work to the corporations, leads to increasing vigilance and greater security, "until it has been said, and with no inconsiderable degree of truth, too, that the very safest place into which a man can put himself is the inside of a first-class railroad-carriage, on a train in full motion."

But, on the other hand, all these appalling disasters seem to have been necessary to secure the improvement of the railway system. There can be no greater mistake than to suppose that men are guided and governed by reason. Most of them are creatures of habit, stupid, sluggish, and prejudiced, and can only learn slowly through calamitous experience. As Mr. Adams says, "To bring about any considerable reform, railroad disasters have, as it were, to be emphasized by loss of life." Indeed, the most instructive part of his volume is the profuse illustration it affords of that inveterate stolidity on the part of railroad managers and officials which nothing could overcome but slaughter, public indignation, murmurs, pecuniary losses—and all this over, and over, and over again—while it has proved impossible even yet to get rid of some of the most serious sources of danger.

The bell-cord for signaling the engineer is a simple device for an important purpose, but it has had a curious history. Nothing certainly would seem to be more essential than for a passenger in case of grave accident to be able to communicate instantaneously with the engine-driver of his train. This is perfectly accomplished by the bell-cord, which has been accordingly long in use in this country. Yet it was not used in England, and its adoption, singular to say, was actively resisted, although they had nothing else to replace it. Mr. Adams says, "An English substitute for the American bell-cord has for more than thirty years set the ingenuity of Great Britain at defiance."

In 1857 the British Board of Trade issued a circular to the railroad companies, pointing out the dangers that arise from lack of proper signal-connection. They say: "From the beginning of the year 1854 down to the present time (December, 1857) there have been twenty-six cases in which either the accidents themselves or some of the ulterior consequences of the accidents would probably have been avoided had such a means of communication existed." But there had not been funerals enough to enforce the recommendation. To get a string attached to a bell for the safety of travelers required a succession of shocks to thrill the country; and they came, of course, in due time. Not only did accidents continue from the setting fire of carriages and throwing them from the rails, but several dreadful instances of assault by maniacs, men with delirium tremens, and criminals, and even outright murder took place, which would undoubtedly have been avoided if there had been any means of communication to stop the train. Several examples are given by Mr. Adams of these terrible occurrences, which "indicate the tremendous nature of the pressure which has been required to even partially force the American bell-cord into use in that country."

But the stolid indifference of railroad conservatism is by no means confined to England. Mr. Adams remarks: "It will not do for the American railroad manager to pride himself too much on his own greater ingenuity and more amicable disposition. The Angola disaster has been referred to, as well as that at Shipton. If the absence of the bell-cord had indeed any part in the fatality of the latter, the presence in cars crowded with passengers of iron pots full of living fire lent horrors almost unheard of to the former. The methods of accomplishing needed results which are usual to any people are never easily changed, whether in Europe or in America; but certainly the disasters which have first and last ensued from the failure to devise any safe means of heating passenger-coaches in this country are out of all proportion to those which can be attributed in England to the absence of means of communication between passengers on trains and those in charge of them. There is an American conservatism as well as an English; and when it comes to a question of running risks it would be strange indeed if the greater margin of security were found west of the Atlantic. The security afforded by the bell-cord assuredly has not as yet, in this country, offset the danger incident to red-hot stoves."

Mr. Adams gives an interesting account of the introduction of various other safety appliances on railroads, and shows that they were mostly repetitions of the bell-cord experience. Among these improvements none are more important than the brakes under the control of the engineer, for quickly stopping trains running at high speed. The American Westinghouse brake, by which an air-pump, attached to the boiler of the locomotive and controlled by the engineer, forces atmospheric air through tubes running under the cars, by which the brake-blocks are pressed against the wheels, is incontestably the most perfect contrivance for quickly stopping trains that has yet been invented, as by means of it the hand of the engine-driver is in fact upon every wheel in the train. This contrivance was of course delicate, and was at first liable to get easily out of order; but it was gradually perfected so as to become automatic and thoroughly trustworthy. "In this country, the superiority of the Westinghouse over any other description of train-brake has long been established through that long preponderance of use which in such matters constitutes the final and irreversible verdict." But in Great Britain its introduction was vigorously resisted, and, as it was energetically pushed, there grew up a war among the different contrivances, to which Mr. Adams devotes an interesting chapter under the title of "The Battle of the Brakes." A royal English commission on railroad accidents was appointed, and undertook a series of competitive trials with the different inventions. "Eight brakes competed, and a train consisting of a locomotive and thirteen cars was specially prepared for each. With these trains some seventy runs were made, and their results recorded and tabulated; the experiments were continued through six consecutive working-days. The result of the trials was a very decided victory for the Westinghouse automatic, and upon its performances the commission based its conclusion that trains ought to be so equipped that in cases of emergency they could be brought to rest when traveling on level ground at fifty miles an hour within a distance of 275 yards." The result was sufficiently decisive, and the Board of Trade urged upon the English companies the adoption of the brake which had proved to be most efficient for its purpose. But there were too many parties interested in rival devices, and the superior one came into use, but very slowly. It did make progress, however, and we are told that the issue is now narrowed down to a struggle between two American brakes, the Westinghouse and the Smith vacuum, which has been its strongest rival.

As to the comparative safety of travel on the railroads in England and in this country, it is conceded that the former have the advantage, although exactly to what extent it is impossible to say, owing to the gross incompleteness of American statistics. But the causes of accidents act very unequally in the two countries. For example, while from failure of bridges, viaducts, or culverts, there were, in six years, in England, only twenty-nine accidents, there were in this country, for the same time, one hundred and sixty-five accidents due to similar causes. The English lead in accidents from collisions of trains, and we in accidents from trains being thrown from the track. "The English collisions are distinctly traceable to constant overcrowding; the American derailments and bridge accidents to inferior construction of our road-beds."

The subject of railroad statistics, including accidents, has received more attention in Massachusetts than elsewhere in this country. The following statement by Mr. Adams will excite some surprise: "During the four years 1875–'78 it will be remembered a single passenger only was killed on the railroads of Massachusetts in consequence of an accident to which he, by his own carelessness, in no way contributed. The average number of persons annually injured, not fatally, during these years, was about five; yet during the year 1878, excluding all cases of mere injury, of which no account was made, no less than fifty-three persons came to their deaths in Boston from falling down stairs, and thirty-seven more from falling out of windows; seven were scalded to death in 1878 alone. In the year 1874, seventeen were killed by being run over by teams in the streets. During the five years, 1874–'78, there were more persons murdered in the city of Boston alone than lost their lives as passengers through the negligence of all the railroad corporations in the whole State of Massachusetts during the nine years 1871–'78; although in these nine years were included both the Revere and the Wollaston disasters, the former of which resulted in the death of twenty-nine and the latter of twenty-one persons.

The most prolific source of railroad accidents is reckless walking and sauntering upon the tracks—a practice in violation of the law, and for which the companies are not responsible. Walking upon the railroad-track is, in this country, regarded as a kind of right of the American citizen which he pays for liberally, nearly fifty per cent. of all accidents which occur being due to this cause. Under the English monarchy the people are kept off the tracks more effectually, and the accidents from this source are accordingly only about seven per cent. of the whole number.

REMOVING THE BARRIERS OF COMMERCE.

We print a translation of the address delivered before the International Congress at Paris, by M. Charles de Fourcy, on the several projected routes of an Interoceanic Ship-Canal across the Isthmus of Darien. M. de Fourcy is a distinguished French engineer, and Inspector-General of Roads and Bridges in France, an eminent and responsible position in that country. He was a delegate to the Congress, a member of its "Technique" Committee, and President of the second Sub-Committee into which it was divided to simplify its labors. On the afternoon of the day preceding the final vote he reviewed the subject in a speech which was listened to with close attention, and, as we are informed by Mr. Nathan Appleton, who was a critical observer of the proceedings, his statement of the relative advantages and disadvantages of the different contemplated lines was undoubtedly influential in determining the vote of the Congress in favor of the Panama route.

We have had engraved, to accompany the article, two very instructive maps, one representing the location of the different routes under consideration, and the other showing the relation which this project bears to the oceanic commerce of the world.

Without venturing to decide which is the best route—a question that belongs to the engineers—we are clear as to certain of the considerations which should have weight in determining it. That the canal must come is inevitable. The Isthmus barrier is a hindrance to commerce—a kind of natural tariff that must be removed in the interest of advancing free trade. It must disappear with other old restrictions on the world's exchanges. It will be a step forward in civilization, and is in the strictest and largest sense an international affair. Commerce is pacific; war and the military spirit are its deadly foes. It is, therefore, of the first necessity that the enterprise should be "hedged about with ample international guarantees of perpetual neutrality." The opening of a water-way across the narrow strip of land that separates two oceans is a world's measure, and ought not to be complicated with any local political considerations. The talk about "patriotism" and the "Monroe doctrine" in connection with this great project is therefore impertinent. It springs from the same narrowness of national feeling that has killed our foreign commerce by prohibiting American citizens from buying ships where they please, and it is a policy which will be condemned by all liberal-minded people.

LITERARY NOTICES.

Is Life worth Living? By William Hurrell Mallock. New York: G. P. Putnam's Sons. Pp. 323. Price, $1.50.

This work, which has recently attracted considerable attention, is a sort of theological manifesto directed against the tendencies of modern science. Those who have arrived at what may be called the conundrum-stage of mental development, and do not object to irreverent impudence, may be pleased with it. Its author is a young English writer, who made a hit with his impertinent satire, "The New Republic," and, having sustained his reputation by various sensational contributions to the periodicals, he now comes jauntily forward with his grand question as to the worth of life, to which his book is an answer. He anticipates the work of the day of judgment by summing up the experiment of universe-making and estimating the net value of the result.

Mr. Mallock is well skilled in rhetorical and dialectic art, and writes in a lively and spirited way. To the amusement-seeking, novel-reading mind, ever on the lookout for a new sensation, and with a frivolous side-interest in religious matters, we should say that the book may be entertaining; but, viewed as a deliverance of sober thought addressed to sensible people, it is a book of nonsense.

The pert effrontery of Mr. Mallock's question, and the unutterable stupidity of the conclusion to which his logic brings him, are apparent at a glance. The question whether life is worth living, of course involves the question of the value of existence and the universe, for life is the grand outcome of the order of Nature. It is something that has arisen by slow degrees and through innumerable forms and grades, during immeasurable time, and is the agency by which the human mind has come into being and reached its present perfection. Life is therefore the thing that has been aimed at, in the onworking of universal law, for more millions of years than we are at liberty to talk about. Life is not a foreign and mysterious something that has been thrust into the system of nature, but it is itself the property and purpose and highest issue of that system. The completest type of organism has been reached through countless ages of struggle and profuse destruction of the lower grades of creatures. In those distant periods Mallock was only a potentiality, and it has been a very expensive process to bring him to pass. A few years ago Mallock was but a globule of English protoplasm, involving whatever life-possibilities heredity had imparted to it. He grew from a germ until his brain acquired the power of thinking and asking questions. He is a product of that long process of life-unfolding that makes him now competent to reason about the universe, and to deduce from it ideas of the existence and attributes of God. Having been brought forth in this way as a result of cosmical operations to which no bounds can be discovered either in time or space, he looks about him and asks whether the whole concern is not a blunder and a fizzle. And the question he raises he is abundantly ready to settle. We might perhaps ask for some suspension of judgment on the ground that, as the universe is in a state of evolution, and has come up from a lower or more worthless condition to a higher or more worthy one, it will go on increasing in worthiness so as finally to become tolerable, if not valuable. Granting that Mallock is no great result, possibly we might, after a time, get something better than Mallock. But he allows no postponement of judgment. He has all the data of the case, and is prepared with a final conclusion. He argues the subject through three hundred and twenty-three pages of his book, and the upshot is a contingent answer. Life is worth living, if you belong to a particular theological school; if you belong to any other theological school, or to no school at all, it is not worth a pin. If you are a Methodist, or a positivist, or a pagan, life is not worth living, but if you are a Roman Catholic, it is. When the mental evolution of man lands him in the bosom of the Papal Church, the long process was well worth while; when it leaves him elsewhere, it is a dead failure. We have here the last brilliant exploit of the theological mind in its warfare with modern science.

The logical implications of Mr. Mallock's position are somewhat curious. He holds that there is no sound morality without Christianity, and no Christianity without a hell. When the heretic and the unbeliever and all beyond the pale of Mother Church die, they sink into perdition, but when the true Catholic dies he has a passport to the happiness of heaven. Now, one would think that this is decisive as to which parties should most prize the continuance of life. Life ought to be best worth living to those who have most to lose when it terminates, and least worth living to those who have everything to gain when it comes to an end. But great is the mystery of logic to those who vacate their reason in deference to infallible authority.

Naval Hygiene: Human Health and the means of preventing Disease. With Illustrative Incidents derived from Naval Experience. By Joseph Wilson, M. D., Medical Director, U. S. N. Second edition, with Colored Lithographs. Philadelphia: Lindsay & Blakiston. 8vo, pp. 274. 1879. Price, $3.

Wherever human beings live together in considerable numbers for any length of time, we expect the conditions of health will soon become impaired unless constant and well-directed efforts are made for their protection; and, in spite of the popular notion to the contrary, life on shipboard is no exception to the rule. Indeed, there are few places where sanitary precautions are more necessary, or where they may be applied with better effect.

The present work is intended as a help in this direction, and contains much that, if brought together in a compact form, would be of service to medical officers and others filling responsible positions in the naval and mercantile marine. The author has chosen, however, to include a great deal that has only a remote relation to the subject, and that here serves merely to encumber and obscure what could otherwise be made practically available. Fifty pages, for example, are given to zoölogy and botany, while the immensely more important subjects of clothing, food and its preservation, the storage and management of the water-supply, and the cleansing and ventilation of the ship, are compressed into an almost equal space; and much of this even is taken up with matter that has little bearing on the topic under discussion.

The chapter on epidemics adds nothing whatever to our knowledge of their causes or prevention, says not a word concerning the measures requisite for their management when occurring on shipboard, and leaves us in doubt as to whether the author is even acquainted with the results of modern investigations on the subject. Had he been, we should scarcely expect to find such a paragraph as this on epidemic influences: "The cause and nature of this epidemic influence are quite unknown. The most ancient theory is as true as any God so ordained it; has thus organized his creatures. Anciently, these diseases were mostly attributed to his wrath; and certainly they mostly result more or less directly from violations of his known laws. When we seek for the instruments of his will in this matter, we get into a labyrinth of guesses, and ingenious and plausible theories, in which hydro-carbons, fermentations, organic germs, microscopic animalcules, and cryptogamic vegetations are made prominently to figure. They nearly all refer to impurities or distemperatures of the atmosphere."

After this, we are not surprised to find the following statement concerning the spread of yellow fever: "In regard to the question of quarantine in this disease, we may safely say that all restraints that prevent the sick from reaching a healthy locality are absurd, and, with our present knowledge on the subject, outrageously cruel—little better than deliberate murder. A yellow-fever patient, even carrying his clothing and bedding with him, has never been known to communicate the disease to another person in a healthy locality, and the experiment has been tried thousands of times."

Chapters XXIV. to XXVIII. inclusive are devoted to certain endemic diseases, among which scorbutus and typhus are the only ones particularly liable to occur on shipboard, and even in the case of these there is a conspicuous absence of specific directions for their prevention. Why such diseases as plica polonica, goitre, elephantiasis, cholera infantum, milk-sickness, and puerperal fever should be discussed in a work on naval hygiene, we fail to understand; and for the addition of an appendix, devoted exclusively to the subject of weights and measures, there seems no other explanation than a desire to fill up the book. Indeed, from beginning to end, the idea is forced upon us that bulk rather than quality has been the principal object.

As before remarked, there are scattered through the pages of the book many good suggestions, that might be made of use had readers the time and patience to hunt them out; all, however, so far as we have observed, may be found in other works on hygiene, and in a far more accessible and less costly shape.

The Silk Goods of America: A Brief Account of the Recent Improvements and Advances of Silk Manufacture in the United States. By William C. Wykoff. Published under the Auspices of the Silk Association of America. New York: D. Van Nostrand. 1879. Pp. 120. Price, $1.50.

The author of this work claims that American silk goods are better as well as cheaper than foreign, and that it is time their actual merits were laid before the public. Every wearer of silk goods, or consumer of sewing-silk and twist, will be interested in the information conveyed in the various chapters upon raw silk; upon sewings and twist; upon weaving; upon black dress-goods; various piece-goods; spun silk; handkerchiefs and ribbons; trimming and *passementerie*; silk laces; dyeing, etc.

From the profusion of interesting information with which the pages of this volume are crowded, we extract quite at random the following. The lengthier statements and explanations are, perhaps, more instructive than the brevities we have chosen.

We are told that the manufacturer wants reeled silk and not cocoons. Its value depends upon the way it is reeled, which is best done at a filature, where cheap skilled labor can be obtained. There are no filatures in this country. Our raw silk comes from abroad—about twenty-four per cent. from Europe and the rest from Asia. The Japanese now have filatures, and send us silk equal to the best from Europe. The coarse, inferior silks are kept at home, and America gets the best and finest. Raw silk is costly and of small bulk, so that its freight is trifling, though it comes so far. By the opening of direct routes to Asia, our silk comes more quickly, thus diminishing the cost of insurance, of interest on capital, and the risk of change of price while on the way. Our importation was greater last year than ever before, being 1,590,666 pounds. The market for silk goods is little affected by the fluctuation in price of raw silk.

The manufacture of silk thread has reached a point with us that defies competition. The superiority of our spooled silk over the foreign was apparent at the Centennial Exposition, and the Europeans have lost their trade here. At first our sewing-silk was made in skeins, but the sewing-machine has revolutionized this branch of the business. Our silk thread did not at first permit the shuttle to pass through the loop that was carried down by the needle; but after many experiments it was found that, by twisting the strands from right to left instead of the other way, it answered the purpose perfectly, and this is machine-twist. The most sedulous care is taken in the manufacture and dyeing. "There is still some difference of opinion in the trade as to whether one ounce of dye to twelve ounces of pure silk, or four to twelve, will give the most serviceable thread. The two kinds are known as thirteen-ounce or pure dye, and sixteen-ounce or standard dye. The standard of purity is closely adhered to, and has helped us to win in the struggle with the foreign thread. Few European threads equal our own in purity. In making colored silk thread, we have reached a high point of delicacy. If we depended for this upon European mills, the color desired would be out of fashion before the thread arrived.

As to the weaving of silk, it is said that we are obliged to import the very best raw silk, owing to the high price of labor here—poor silk requiring great cost in labor. "It costs five times as much to tie a knot here as in France." In the best silk, the thread is not lumpy; but, in weaving the lumpy thread of poor silk, the weaver is constantly busy picking off the imperfections. This is in hand-weaving, which is the prevalent mode in Europe. We use power-looms. In the manufacture of plain black-silk goods we have a system of our own which has grown up in this country. We quote the following method of testing the purity of silks: Ravel out a few threads and pass them through and over the fingers. "In heavily dyed silk the particles of dye will make the threads feel rough and lumpy to the touch. Then by wetting the lint, the goods weighted by dye will be readily distinguished by the dye coming out under pressure. Another simple but effective test of purity is to burn a small quantity of the threads. Pure silk will instantly crisp, leaving only a pure charcoal; heavily dyed silk will smolder, leaving a yellow, greasy ash." One of our most sanguine manufacturers declares his belief that within ten years the dress-silks of this country will bear a higher reputation than those made anywhere else in the world.

In figured dress-silk goods, raw material bears a greater proportion to labor. Our designs are original, changing in color and pattern with the seasons. They are mostly made on power-looms, are firm, serviceable, and very cheap. The Jacquard machines on which they are woven came at first from England and France; but they are now wholly made here, and adapted to our requirements. They are the same in principle but run more smoothly, and can be applied to more intricate patterns, and obtain a higher speed. In making satins and grenadines we have also produced great improvements. Although these goods are so unlike, we were the first to make grenadines with satin stripes, and have added a brocaded pattern that permeates both. We do not yet succeed with silk velvet. Refinishing is a large business here. Heavy calendering-machines of 300 tons' power are used, and the pressure can be varied from five pounds to 60,000. Some goods go through hot rolls and some through cold, and the surface of the roll may convert plain silks into striped ones or into *moire antique*. The proper pressure gives to brocade definiteness of outline, and to satin its full luster. Damaged goods acquire freshness, old fashions are changed to new, and "hard silk" to soft, by the finishing process. In the matter of umbrellas we are at last achieving success. Some made here, from ferule to handle, have survived the storms of successive years, and are still fit for service.

Spun silk is made from "waste" silk. The sources of waste silk are, cocoons of irregular formation, the tangled floss from filatures, and raw silk more or less tangled in the silk-mill. It is pure silk that can not be reeled. It is prepared for spinning by the most delicate processes, and when ready looks like the whitest of combed fleeces, and has a luster equal to that of spun glass. It can be spun with perfect smoothness and of any size. Spun and reeled silks are becoming more and more interchangeable in the manufacture of fabrics. The two methods of making cheap, showy silks are either by weighting slight material with dyestuff, or by using spun silk. Brocades for ball- and wedding-dresses are often of spun silk.

American-made handkerchiefs, scarfs, neckties, and millinery goods, compete successfully with the foreign supply, and keep down prices for consumers. In ribbons our success is complete. Only inferior ribbons are now imported in any quantity. In comparison with ours the foreign ribbons are overweighted and of inferior silk. The designs originate in our own factories, and are much admired abroad. They are made upon power-looms, of which we have the best in the world. In the making of trimmings and of lace, the details given in this work are very interesting, but we have no more space at our command. We must also omit the subject of dyeing, which, though the last in order, is by no means the least interesting.

The remainder of the volume is taken up with statistics of the silk manufacture; and the "Seventh Annual Report of the Silk Association of America," in which the progress of the past year is summarized, is also added.

A Contribution to the Geology of the Lower Amazonas. By Orville A. Derby, M. S. Pp. 24.

The scientific world is chiefly indebted to the late Professor Hartt for recent accurate and detailed investigations of the geological structure of eastern Brazil, and of the lower Amazon and its tributaries. But the untimely death of Professor Hartt, with various other causes, has delayed the publication of the extensive reports he had prepared; and we have in the present pamphlet a *résumé* of the work which they cover, furnished by his friend and assistant Mr. Derby. The author also includes the results of some of his own researches in the same field, made subsequently to those of Professor Hartt. The great valley of the Amazon, according to these investigators, first appeared in early Silurian times as a wide strait between two islands or groups of islands, one forming the base of the Brazilian plateau, and the other that of the plateau of Guiana. The rise of the Andes converted the western part of the strait into a basin, and subsequent oscillations have determined the character and succession of deposits in the geological development of the region. The evolution of the great valley terminated with the formation of the vast flood-plain which now covered with forest extends from the Atlantic to the foot of the Andes.

Primitive Manners and Customs. By James A Farrer. New York: Henry Holt & Co. Pp. 315. Price, $1.75.

This book will do very well as a stepping-stone to the ethnological treatises of Tylor, Lubbock, Bancroft, and Peschell, on the life of the lower races of mankind. It gives an entertaining account of the ideas, habits, and peculiarities of savage and half-civilized tribes, taking up in successive chapters their "Myths and Beliefs," their "Modes of Prayer," "Proverbs," "Moral Philosophy," "Political Life," "Penal Laws," "Wedding Customs," "Fairy Lore," and "Comparative Folk Lore." The author writes in a liberal spirit, but rather avoids the controversial topics raised by investigators in this field. In his introduction he remarks:

The vexed question, whether savage life represents a primitive or a decadent condition, whether it represents what man at first everywhere was, or only what he may become, has throughout the following chapters been avoided, that controversy being regarded as "laid" by the exhaustive researches of Mr. Tylor and other writers. But, while the state of the lowest modern savages is taken as the nearest approximation we have of the primitive state from which mankind has risen, it is not pretended that the state of any particular tribe may not be one to which it has fallen. As the low position of many Bushmen tribes is quite explicable by their long border warfare with the Dutch, and the consequent cruelties they were exposed to, or as the state of many Brazilian savages may be traced to similar contact with the Portuguese, so any case of extreme savagery may be the result of causes whose operation has no historical or no written proof to attest them. The gigantic stone images on Easter Island, or the great earthworks in America, are among the proofs that but for such material traces of its existence it is possible for a whole civilization to vanish, and to leave only the veriest savages on the soil where it flourished. As we know that Europe was once as purely savage as parts of Africa are still, and can conceive the cycle of events restoring it to barbarism, so in the depths of time it may have happened in places where no suspicion of such a history is possible. As the surface of the earth seems subjected to processes of elevation and subsidence, land and sea constantly alternating their dominion, so it may be with civilization, destined to no permanent home on the earth, but subsiding here to reappear there, and varying its level as it varies its latitude.

As the practical infinity of past time makes it impossible to calculate the influence exercised in different parts of the world by migrations, by conquests, or by commerce, except within a very limited period, so it precludes any definite belief in ethnological divisions, and relegates the question of the unity of the human race, like that of its origin, to the limbo of profitless discussion. No characteristic has yet been found by which mankind can be classified distinctly into races: and with all the differences of color, hair, skull, or language, which now suffice for purposes of nomenclature, it remains true that there is nothing to choose between the hypothesis that we constitute only one species and that we constitute several. The world is so old as to admit of several divergences from a single original type quite as wide as any that exist; while, on the other hand, similarity of customs (such, for instance, as that Tartars in Asia, Sioux Indians in America, and Kamschadels should all regard it as a sin to touch a fire with a knife) fail us as a proof of a unity of origin, in the face of our ignorance of prehistoric antiquity.

Should he have succeeded in making any one think better than before, with more interest and sympathy of those outcasts of the world whom we designate as savage, something will at least have been done to claim for them a kindlier treatment and respect than in popular estimation they either deserve or obtain.

Papers read before the Pi Eta Scientific Society, 1878–'79. Rensselaer Polytechnic Institute, Troy, N. Y. Pp. 69.

This is a collection of ten papers on various subjects, most of which fall under the head of engineering. The first, by S. Edward Warren, on "Graphic Science in Text-book and Teaching," is an explanation of "the idea and intended use" of each volume of a series of text-books prepared by the author on this subject. The second is a technical paper by Hugo Gylden, Director of the University Observatory, of Stockholm, "On the Relations between the Number, Brightness, and Relative Mean Distances of the Fixed Stars as seen from the Earth," translated by Professor E. S. Holden, of the Washington Naval Observatory and Lieutenant Eric Bergland, U. S. Engineer Corps. Among the remaining papers, "Iron and its Uses in Permanent Structures," by C. J. Bates, and "Tides in the Upper Hudson," by John A. Ferris, are of considerable popular interest. A list of the members of the society is appended.

American Ornithology; or, The Natural History of the Birds of the United States. Illustrated with Plates made from Drawings from Nature. By Alexander Wilson and Charles Lucien Bonaparte. Philadelphia: Porter & Coates. Pp. 788. Price, $7.50.

This book does not sufficiently explain itself. There are two volumes bound in one; there are prefixed to it twenty-seven plates containing three or four hundred engravings of birds; there is Baird's list of American species of 1856; and a biography of Alexander Wilson, made up chiefly of his letters. Two names appear upon the title-page as authors, but, if there is any statement of their respective shares in the production of the work, we have failed to observe it.

Alexander Wilson, the ornithologist, was a Scotchman, born in 1766, the son of a distiller, and who himself became a weaver. He early dabbled in poetry, and emigrated to Pennsylvania in 1794. He maintained himself at first by peddling and teaching school. During his journeys he became interested in birds, and at length devoted himself to that branch of natural history. He learned drawing, coloring, and etching, and projected a comprehensive work on American birds. Having prepared a large number of fine illustrations, he made tours through the country to extend his ornithological observations and to get subscribers to his work, which was to appear in successive volumes, and to cost altogether $120. He was but poorly sustained, getting many compliments for the beauty of the pictures he presented, with but very little substantial support. The first volume appeared in 1808. He had completed the publication of seven volumes when he died, in 1813, and the eighth and ninth volumes were subsequently edited by George Ord.

Charles Lucien Bonaparte, son of Lucien Bonaparte, the second brother of Napoleon, was born in Paris in 1803, and in 1822 he married the daughter of Joseph Bonaparte and went to Philadelphia, where he joined his father-in-law. He was an ardent naturalist, and devoted himself especially to the subject of birds. He published "American Ornithology," in four volumes (1822–'33), thus continuing Wilson's great work. He added descriptions of over one hundred new species of birds discovered by himself, and which are designated in the lists of the work before us.

The present popular edition of "American Ornithology," now issued in one portly volume by Porter & Coates, is evidently based upon the elaborate publications of these two naturalists, and the work has a permanent interest, both from its early and original observations, and as representing a portion of the history of American science.

The Rosicrucians: Their Rites and Mysteries, with Chapters on the Ancient Fire and Serpent Worshipers, and Explanations of the Mystic Symbols represented in the Monuments and Talismans of the Primitive Philosophers. 300 Illustrations. By Hargrave Jennings. New York: J. W. Bouton. Pp. 372.

We gather but little more from looking over this book than is conveyed by the title. It has a great number of mysterious symbolic pictures; and its text is of mysterious people and mysterious things. There *may* be wisdom in it, nevertheless.

The Antiquities and Platycnemism of the Mound-Builders of the State of Wisconsin. By J. M. De Hart, M. D. Pp. 15. Illustrated.

In this pamphlet Dr. De Hart briefly describes a few of the more remarkable mounds belonging to a group found near Lake Mendota, in the State of Wisconsin. Like the mounds in other parts of the State, these are mainly of two sorts, animal mounds, or those made in imitation of the forms of animate objects, and mounds of circular or oblong form, with a more or less conical or pyramidal elevation, some of which contain human and other remains. Of the former, which usually represent the animals they are meant to imitate, on an immensely extended scale, the author describes one that is shaped like a bird with wings expanded, each wing measuring about 300 feet in length; another in the form of a squirrel with a tail over 500 feet long; a third representing a deer; a fourth a bear, etc.

The largest of the circular mounds was opened by the Doctor, and found to contain, besides ashes, flints, and other *débris*, three human skeletons, presenting in each case types of structure characteristic of the mound-builders. The most marked of these peculiarities, viz., the flat shin-bones, and the perforation at the inferior extremity of the humerus, are discussed by the author.

The Silkworm. Being a Brief Manual of Instruction for the Production of Silk. With Illustrations. By Professor C. V. Riley. Washington, 1879. Pp. 31.

This forms Special Report No. 11 of the Department of Agriculture, of which at the time of its publication Professor Riley was entomologist. It opens with an introduction in which the causes that have hitherto retarded the growth of the silk industry in this country are pointed out; and the subject of profits in the different branches of the business quite fully considered. Next we have an interesting and instructive account of the natural history of the silkworm, including its diseases; followed by directions for rearing, and for the management required in order to obtain the largest returns, either in silk or eggs. The operation of reeling both by the old and the improved methods is described; and the pamphlet closes with a brief description of the food-plants of the silkworm. A glossary is appended, explaining the few technical terms the author was obliged to employ.

The Geology of the Diamontiferous Regions of the Province of Paraná, Brazil. By Orville A. Derby, M. S. Pp. 8.

This short paper contains a good many interesting facts about the geological relations of the diamond and the methods adopted in mining for them. They are found in the valley of the Zibagy and tributary streams, in the sands, in pot-holes, and in gravel-banks. The diamonds appear to have been washed out of the Devonian sandstone of that region, but the author thinks they were previously derived from metamorphic rocks, and deposited in the sands which afterward went to form these sandstones. That they did not originate in the latter is proved, he thinks, by the fact that it contains no traces of metamorphism or of crystallization.

First Step in Chemical Principles. An Introduction to Modern Chemistry, intended especially for Beginners. By Henry Leffman, M. D. Philadelphia: Edward Stern & Co. Pp. 52. Price, 50 cents.

A beginner of some maturity of mind, say a young medical student, who knew nothing whatever of the subject, might derive advantage from reading over this brief introduction; but it is not a "First Step" in any sense that it could be used in a primary school to start young beginners. It contains a very readable summary of chemical principles, but they are presented in the elaborated thought and technical language of the developed science.

The Young Folks' Cyclopædia of Common Things. By John D. Champlin, Jr. With numerous Illustrations. New York: Henry Holt & Co. Pp. 690. Price, $3.

Mr. Champlin has here hit upon an excellent idea, and has carried it out very successfully. There was room for a popular book on common things much more full than the current "familiar science" manuals. A great deal of miscellaneous information on ordinary objects and subjects has been collated and digested in alphabetical order convenient for reference, and the editor is right in calling attention at the outset to the need of encouraging in the young the practice of consulting works of reference. The volume will be found most useful in families, as both the knowledge it imparts and the form of its presentation are well suited to satisfy the curiosity of young minds. A good deal of information is given about the common sciences, such as astronomy, chemistry, physics, natural history, and physiology, and about heat, light, air, electricity, and the parts and operations of the human system. There is much about the modes of manufacture of common articles, and the natural history of the more familiar and important animals and plants is fully presented. The book is compiled with judgment, Mr. Champlin having undergone his apprenticeship at this kind of work on the "American Cyclopædia." We are glad to notice that Holt puts the book at a quite reasonable price.

Twenty Lessons in Inorganic Chemistry. By W. G. Valentin, F. C. S. G. P. Putnam's Sons. Pp. 184. Price, $1.

This claims to be an elementary book for students to begin with, but the beginning must be in the old lecture-room form of instruction. The author says: "It is not enough, as every teacher knows, to exhibit experiments before a class, unless they are made subservient to explain the theory of the science, and to place it on a sound basis. All theoretical explanations should be based upon experiments which fix it upon the memory. This is the plan which I have laid down for my guidance." As might therefore be expected, the book is filled with illustrations and descriptions of lecture-room experiments, and the usually accompanying explanations and information. It is clear, accurate, and well executed.

The Value of Life. A Reply to Mr. Mallock's Essay, "Is Life worth Living?" New York: G. P. Putnam's Sons. Pp. 253. Price, $1.50.

An anonymous writer, thinking Mr. Mallock's book worth answering, has replied to his arguments very fully and ably in this volume. The book is written from the Positivist point of view, in the more special sense of the term. By Positivism, Mr. Mallock means those later tendencies and theories of science which bear upon the higher questions of religion, morality, and polity, and as illustrated in the writings of such thinkers as Clifford, Huxley, Tyndall, and Mill, but Mr. Mallock's critic rather means by "Positivism" the doctrines of Comte; and this reply is chiefly interesting as dealing with Mr. Mallock's questions from that point of view.

PUBLICATIONS RECEIVED.

The Mound-Builders. By J. P. Maclean. Illustrated. Cincinnati: Robert Clark & Co. 1879. Pp. 233, with Map. $1.50.

The Arctic Voyages of Adolf Erik Nordenskjold, 1858–1879. With Illustrations and Maps. London: Macmillan & Co. 1879. Pp. 447. $4.50.

A Text-Book of Physiology. By M. Foster, M. D., F. R. S. With Illustrations. Third edition, revised. London: Macmillan & Co. 1879. Pp. 720. $3.50.

The Native Flowers and Ferns of the United States. By Thomas Mehan. Vol. I. Parts I. to VIII. Illustrated.

Insect Lives, or Born in Prison. By Julia P. Ballard. Cincinnati: Robert Clark & Co. 1879. Pp. 97. $1.

Electricity, as related to Medicine and Surgery. By A. D. Rockwell, M. D. New York: William Wood & Co. 1879. Pp. 99. $1.

American Health Primers. The Throat and the Voice. By J. Solis Cohen, M. D. Pp. 159. The Summer and its Diseases. By James C. Wilson, M. D. Pp. 160. Winter and its Dangers. By Hamilton Osgood, M. D. Pp. 160. Philadelphia: Lindsay & Blakiston. 1879. 50 cents each.

Report of the Geology of the Henry Mountain. By G. K. Gilbert. Washington: Government Printing-Office. 1877. Pp. 160. 5 Maps.

Report on the Lands of the Arid Region of the United States. With a more Detailed Account of the Lands of Utah. By J. W. Powell. Second edition. Washington: Government Printing-Office. 1879. Pp 195, with Maps.

A Dictionary of the German Terms used in Medicine. By George R. Cutter, M. D. New York: G. P. Putnam's Sons. 1879. Pp. 304. $3.

Protection of Forests a Necessity By S. v. Dorrien. New York: For sale by B. Westerman & Co. 1879. Pp. 33.

Labor-making Machinery. By Frederick Perry Powers New York: G. P. Putnam's Sons 1880. 25 cents.

A Dictionary of Music and Musicians. Edited by George Grove, D. C. L. Vol II., Part VIII. London and New York: Macmillan & Co. 1879. Per part, $1.25.

Brazilian Corals and Coral Reefs. By Richard Rathbun. Illustrated. Pp. 13. Reprinted from "The American Naturalist."

A List of Brazilian Echinoderms. By Richard Rathbun. Pp. 20. From "Transactions of Connecticut Academy of Sciences."

On the Present Status of Passus Domesticus in America. By Dr. Elliott Coues. Pp. 18.

The Brush-System of Electric Lighting. By C. F. Brush, M. E. Cleveland: Wiseman & Harvey. 1879. Pp. 26.

Neurotomy, a Substitute for Enucleation. By Julian J. Chisholm, M. D. Richmond: J. W. Fergusson print. 1879. Pp. 16.

The Geological and Natural History Survey of Minnesota. Seventh Annual Report for the Year 1878. Minneapolis: Johnson, Smith & Harrison. 1879.

Abuses in Medicine. A Lecture. By J. Logan, M. D., etc. New York: National Printing Co. 1879. Pp. 47.

How the Geometrical Lines have their Counterparts in Music. By Isaac L. Rice. New York: Asa K. Butts. 1880. Pp. 31.

Unity Pulpit, Boston. Sermons of M. J. Savage: October 31, 1879. "The Truth about Sunday"; November 7, 1879. "The Origin of Goodness"; November 14, 1879. "The Nature of Goodness"; November 21, 1879, "Life and Death"; November 28, 1879, "The Sense of Obligation." Boston: George H. Ellis. $1.50 per year; 6 cents per copy.

Gaspard D. Coligny (Marquis de Chatillon). By Walter Besant, M. A. New York; G. P. Putnam's Sons. 1879. Pp. 232. $1.

Mechanics. By Robert Stawell Ball, F. R. S. New York: Henry Holt & Co. 1879. Pp. 170. 60 cents.

On the Fertilization of Yucca. By Thomas Mehan. Reprint from "The North American Entomologist." Pp. 4. On Sex in Castanea Americana. By same. Pp. 2. The Law governing Sex. By same. Pp. 3.

"The Kansas Review," Collin Timmons, Editor. Vol. I., No. 1. Lawrence, Kansas, November. 1879. Monthly, 75 cents per annum; 10 cents per copy.

Quarterly Report of the Chief of the Bureau of Statistics relative to the Imports, Exports, Immigration, and Emigration of the United States, for Three Months ending June 4, 1879. Washington: Government Printing-Office. Pp. 96.

Geological Survey of Alabama. Report of Progress of 1877 and 1878. By Eugene A. Smith, Ph. D., State Geologist. Montgomery, Alabama: Barrett & Brown. 1879.

Topographic, Hypsometric, and Meteorologic Report. By William Libbey, Jr., and W. W. McDonald, of the Princeton Scientific Expedition. Illustrated. New York. 1879. Pp. 83.

Investigations on Rainfall, Percolation, and Evaporation of Water from the Soil, Temperature of Soil and Air, etc., etc., at the Massachusetts Agriculturist College, Amherst, Massachusetts. By Professor Levi Stockbridge. Boston: Rand, Avery & Co. 1879. Pp. 38.

American Science Series. Astronomy. By Simon Newcomb and Edward S. Holden. Henry Holt & Co. 512 pages. Price $2.50.

POPULAR MISCELLANY.

Education of the Color-Sense.—Though it is but a few years since general attention has been directed to the subject of color blindness, the study of its phenomena has shown that there are two forms of the defect, not perhaps sharply separable, but nevertheless quite distinct. In one form there appears to be simply an imperfect or undeveloped sense of color, the power of distinguishing the different colors, though not wholly absent, being far below the normal. In the other form of the defect there is an entire inability to recognize one or more of the primary colors—that is, the blindness is complete so far as particular colors are concerned. Dr. Swan M. Burnett, surgeon in charge of the Ophthalmic Division of the Central Dispensary in Washington, in a short paper entitled "A Systematic Method for the Education of the Color-Sense in Children," expresses the opinion that cases of the first-mentioned variety are susceptible of decided improvement by early and persistent training of the individual. In cases of the other kind, however, which are generally hereditary, he believes that amelioration can be brought about, if at all, only by a course of education applied to successive generations. The author finds fault with the general neglect of the subject in our schools, and also with the methods practiced in the few instances where such training has been attempted. In the Washington schools the practice is to use a chart on which the various colors are painted. These colors soon become so faded and dim as to no longer represent what was originally intended; and, even with this imperfect chart, no systematic instruction is given in the comparison of the colors. The first requisite, in Dr. Burnett's opinion, for successfully teaching color to children is, that the method shall be simple and easy. The study should also be made interesting, so that the children will pursue it more as a diversion than a task. Each child should be taught separately, but the instruction may be carried on in such a manner that the other children can participate. As the main object is to enable the child to discriminate between the various colors, the comparison of one color with another will be the principal part of the work. But the pupil should at the same time be taught the names of the colors and shades, so as to be able to convey the impressions he has received in definite language. To carry out these indications in a simple and effective way, there are required—first, a set of sample colors with which comparisons are to be made; and, second, a collection of colors from which the pupil may choose such as are to be compared with the sample. For the former, Dr. Burnett recommends the following: "Take a half-sheet of white perforated cardboard (42 × 26 cm.) with the largest size perforations, and work into it, with Berlin wool, bars 18 cm. in length and 35 mm. in width, of each of the following colors: red, green, and blue, with a distance of 1·5 cm. between them. These should be as pure as possible, and represent the three primary colors. Then, beginning 3 cm. below, work in at the same distances apart each of the following colors of medium shade and as pure as can be got: purple, orange, yellow, pink, brown, and gray. A single skein of Berlin wool is generally enough to work a bar of the required length and width, which is sufficiently large to be seen distinctly across any ordinary schoolroom by a normal eye. This card is to be placed on a white background on the wall in sight of all the pupils." In the process of instruction the pupils are first familiarized with this card, and with the names of the colors represented on it, and, when able to designate each of these correctly, the teacher will explain what is meant by a "shade," and, taking a package of Berlin wools containing all the shades of the nine colors on the card, will pick out and exhibit to the class all the shades of one of the colors. After this, the shades are thoroughly mixed with the other colors in the pile, and the pupils are then called upon to do the choosing, arranging them in regular order from darkest to lightest. The same process is to be repeated with each of the colors on the card.

Population of Africa.—Accurate statistics of the population of Africa, and especially of the interior portions of the continent, are of course not yet obtainable, and it will probably be many years before several of the populous districts now known will be sufficiently accessible for a thorough census; but much important information has been gathered about the distribution of the inhabitants and the density of the population in the different parts of the country. In the region of the great lakes, for example, there are countries as thickly peopled as many of the states of Europe—relatively small areas which, according to Stanley, possess millions of inhabitants. Behna states that the negro regions are by far the most populous, while the desert parts represent the other extreme. M. A. Rabaud, in a paper published in the "Bulletin of the Marseilles Geographical Society," gives the following as the population of the different subdivisions of the continent: In the Soudan, the population is estimated at 80,000,000, or about fifty-three per square mile; the town of Bida, on the Niger, contains 80,000 inhabitants. The population of East Africa is estimated at 30,000,000, and that of Equatorial Africa at about 40,000,000. One of the latest authorities divides the population as follows among the great families into which ethnologists have separated the peoples: Negroes, 130,000,000; Hamites, 20,000,000; Bantus, 13,000,000; Foolahs, 8,000,000; Nubians, 1,500,000; Hottentots, 50,000. This would give a total population of 172,550,000. These figures are, of course, only approximate, and both German and English geographers think them too low, the former estimating the population at 200,000,000.

About Herrings.—From statistics of the Scottish herring-fisheries, furnished by a writer in "Chambers's Journal," we may get a partial idea of the enormous productiveness and abundance of that species of fish. During a recent year the herrings taken in Scottish waters and cured were sufficient to fill one million barrels, each barrel containing an average of seven hundred fish. This quantity it must be observed represents *cured* fish only, and only those which are caught in Scotland under the superintendence of the Fishery Board. It is pretty certain that as many herrings are captured and offered for sale as fresh fish and "reds" as are cured for the markets in Scotland and offered for sale as salt herrings; which gives us the prodigious total of fourteen hundred millions withdrawn annually from the sea; and even this number, vast as it is, does not include what are used in the form of white-bait, or those which are sold as sprats.

After draining the sea to such an extent, it might almost be supposed that there would be scarcely herrings enough left to suffice for a breeding-stock; but the demands of man are a mere fraction of what are taken out of the shoals. All that are captured, as well as all that are wasted during the capture, and destroyed in the process of curing, sink into insignificance when compared with the vastness of the quantities which are devoured by other enemies of the fish. Cod and ling are known to prey extensively on the herring; and a calculation, based on the number of cod and ling annually caught under the auspices of the Scottish Board of Fisheries (three million five hundred thousand were taken in 1876), assumes that there is a capital stock of these fish in the Scottish firths and seas of seventy million individuals; and that each individual consumes four hundred and twenty herrings per annum, which at the rate of two herrings every day for seven months in the year, shows a consumption of twenty-nine thousand four hundred million individual herrings. Nor does the account stop at this point. The commissioners who recently collected information on the Scottish herring-fisheries, assume that in Scotland alone the gannet (a sea-bird) will annually draw on the shoals to the extent of one thousand one hundred and ten million herrings! In addition to dog-fish, cod, gannets, and other sea-birds, the herring has many other enemies; porpoises, seals, coal-fish, and other predaceous fishes are constantly lying in wait to fall upon and devour them. A female herring, we know, yields over thirty thousand eggs; but at the shoaling-time myriads of those eggs are devoured by a variety of enemies; besides which, hundreds of thousands of the eggs are never touched by the fructifying milt of the male fish, and so perish in the waters.

A Fabled Eastern City.—In a communication to the Royal Asiatic Society of Bombay, M. C. Doughty gives an account of a visit to the so-called rock city of El-Hejjer, which lies upon the Haj road in Arabia, at twenty camel-journeys' distance from Damascus, and about which many extravagant stories are current among the Arabs. In the days of Ptolemy, who calls it Egra, the place was an emporium on the trade-road of gold and frankincense to Syria. Having got there after great fatigue, Mr. Doughty found the fabled seven cities of the Arabs—said to be hewed in as many mountains—to be about a hundred funereal chambers excavated in the sandstone rocks. The city appears, by the traces remaining of foundations, to have been a cluster of four or five palm villages in clay, each surrounded by a wall in the ordinary Arab fashion. In their interiors the funereal monuments are plain sepulchral chambers with sunken tombs in the floor and recesses, while in the walls are shallow shelves of a man's length. Inscriptions are seen handsomely engraved in a panel above the doorways in many of the monuments. Above these again, in the nobler monuments, there is very commonly the thick figure of a bird with outstretched wings. The Arabs say it is a buzzard or a falcon, but Mr. Doughty suggests that the effigies are those of the mortuary owls of the old Arabians. Mr. Doughty's visit has disposed of the singular fables propagated by the Arabs as well as by Turkish and Persian pilgrims, and which, he says, have been accepted in some works of learned Orientalists in Europe.

Cases of Remarkable Precocity.—From an entertaining paper in "Chambers's Journal" we select a few instances of "precocious cleverness." Anne Maria Schurmann was, in her day, the boast of Germany. At the age of six, and without instruction, she cut in paper the most delicate figures; at eight, she learned in a few days to paint flowers, which, it should be added, were highly esteemed; and two years later it cost her only five hours' application to learn the art of embroidering with elegance. Her talents for higher attainments, we are told, did not develop themselves till she was twelve years of age, when they were discovered in the following manner: Her brothers were studying in the apartment where she sat, and it was noticed that, whenever their memories failed in the recital of their lessons, the little girl prompted them without any previous knowledge of their tasks except what she had gained from hearing the boys con them over. In her education she made extraordinary progress, and is said to have perfectly understood the German, Low-Dutch, French, English, Latin, Greek, Italian, Hebrew, Syriac, Chaldean, Arabic, and Ethiopian languages. Her knowledge of science and her skill in music, painting, and sculpture were also extraordinary; and her talent for modeling was shown by the wax portrait she contrived to make of herself with the aid of a mirror.

Another prodigy was Dorothy Schlozer, a Hanoverian lady, who was thought worthy of the highest academical honors of the University of Göttingen, and had the degree of Doctor in Philosophy conferred upon her when she was only seventeen years of age. Before she was three years old she was taught Low-German; and three years later learned French and German; and, after receiving ten lessons in geometry, was able to answer abstruse questions. Other languages were next acquired with singular rapidity; and before she was fourteen she knew Latin and Greek, and had become a good classical scholar. She also made herself acquainted with almost every branch of polite literature, as well as many of the sciences. As an instance of this lady's indefatigable industry, it may be mentioned that she visited the deepest mines in the Harz Forest in the common garb of a laborer, to gain proficiency in mineralogy.

It is said that Blaise Pascal, one of the most profound thinkers and accomplished writers of France, exhibited precocious proofs of genius, especially in mathematics, from his earliest childhood. Having been purposely kept in ignorance of geometry, lest his propensity in that direction should interfere with the prosecution of other studies, his self-prompted genius discovered for itself the elementary truths of the forbidden science. When quite a boy, he was discovered by his father in the act of demonstrating on the pavement of an old hall where he used to play, and by means of a rude diagram he traced with a piece of coal a proposition which corresponded to the thirty-second of the First Book of Euclid. At the age of sixteen he composed a tractate on conic sections, which excited great admiration. Three years later he invented his celebrated arithmetical machine; and at the age of twenty-six he had composed the greater part of his mathematical works, and made those brilliant experiments in hydrostatics and pneumatics which ranked him among the first natural philosophers of his time.

Discrimination and Memory of Sounds.—Some very extraordinary feats of memory are by the "Scientific American" credited to a youth named Hicks, residing in Rochester, New York. Hicks has not lived long in Rochester, having removed thither lately from Buffalo; yet he is able to give the numbers of nearly three hundred locomotives on hearing their bells. During the day he is employed at so great a distance from the railway that he rarely hears a passing train; but at night he can hear every train, as his house is situated near the railroad. Men who have for years been connected with railways admit that at most they can distinguish the sounds of only very few locomotive-bells as compared with the great number Hicks can name almost without thought. Not long ago an old switch-engine, used in the yards at Buffalo, was sent to Rochester for some special purpose. As it passed near Hicks's house he heard the bell, and remarked that the engine was number so-and-so, and that he had not heard its bell for six years. A boarder in the house ran to the railroad and found that the number given was the correct one. Not long since the young man went to Syracuse, and, while there, hearing an engine coming out of the round-house, remarked to a friend that he knew the bell, though he had not heard it in five years. The number which he gave proved to be the correct one.

Lubbock on Science in the Primary Schools.—Sir John Lubbock, advocating in the British House of Commons the cause of science-teaching in schools, urged that elementary science should be placed on an equality in the education-code with grammar, geography, and history. The practical difficulties in the way could be easily overcome, and his proposal, so far from upsetting the equilibrium of the code, would really establish it, seeing that, at present, the code was entirely one-sided, all knowledge of natural phenomena being excluded. It was often said, he urged, that it was ridiculous to teach "ologies" before the children could read and write thoroughly. But, in the first place, it was a misnomer to call the lessons he proposed "ologies"; secondly, it should be remembered that, when children were learning to read, they had to read something, and the question was what that something was to be. He wished for nothing difficult or abstruse, nothing beyond the range of the children's minds and daily experience. "In mechanics, the simple forces might be explained to them—why carts were put on wheels, how levers and pulleys acted, the use of the screw and wedge; then the nature and relative distances of the principal heavenly bodies, the primary facts relating to air and water in agricultural districts, the character of the soil, the reason for the rotation of crops, the origin and principal qualities of such substances as chalk, coal, iron, copper, etc.; the succession of the seasons, the flow of rivers, the growth of plants; the fundamental rules of health, the necessity for ventilation and cleanliness, and, last, not least, the need for industry, frugality, and economy. Explanations of these simple and every-day things would be most interesting and useful to the children. So far from cramming and confusing them, you would introduce light and order into their minds, and give them an interest in their lessons, which, under the present system, they rarely felt."

Ancient Uses of Cork.—A writer in the "Pharmaceutical Journal" has collected a large amount of interesting information on the subject of the cork-tree and its bark, and the uses of the latter in both ancient and modern times. The tree, and the application of its bark to useful purposes, was well known to the Egyptians, Greeks, and Romans. The former used to construct their coffins of this material. Theophrastus, the Greek philosopher, who wrote on botany, etc., four centuries B. C., mentions this tree among the oaks, under the name of *phellus*, and says that it has a thick, fleshy bark, which must be stripped off every three years to prevent it from perishing. He adds that it was so light as never to sink in water, and on that account might be used for many purposes. Pliny describes the tree under the name of *suber*, and relates everything said by Theophrastus of *phellus*. From his account we learn that the Roman fishermen used it as floats to their nets and fishing-tackle, and as buoys to their anchors. The use of these buoys in saving life appears to have been well known to the ancients, for Lucian ("Epist. 1," 17) mentions that two men, one of whom had fallen into the sea, and another who jumped after to afford him assistance, were saved by means of an anchor-buoy. The use of this substance in assisting swimmers was not unknown to the Romans. By Plutarchus, in his "Vita Camilli," we are told that, when the imperial city was besieged by the Gauls, Camillus sent a Roman to the Capitol, who, to avoid the enemy, swam the Tiber with corks under him, his clothes being bound upon his head, and was fortunate enough to succeed in the attempt. The use of cork for stoppers was not entirely unknown to the Romans, and instances of its being thus employed may be seen in Cato's "De Re Rusticâ," cap. cxx.; but its application to this purpose seems not to have been very common, or cork stoppers would have been oftener mentioned by authors who have written on agriculture and cookery, and also in the works of ancient poets. The convivial customs of those days had no connection with the bottle, glass bottles being of a much later invention. Instead of having dozens of sparkling champagne or hock, to be liberated from the bottle by the corkscrew, at their feasts, the guests filled their drinking-cups of gold, silver, crystal, or beech-wood from a two-handled amphora, a kind of earthenware pitcher in which their choice wines used to be kept. The mouths of these vessels were stopped with wood, and covered with a mastic, composed of pitch, chalk, and oil, to prevent air spoiling the wine or evaporation taking place. Columella, who wrote one of the earliest works on agriculture, gives directions for preparing this cement. Pliny, in describing the cork-tree, says it is smaller than the oak, and its acorns of the very worst quality. He tells us the cork-tree did not grow throughout Italy, and in no part whatever of Gaul. At the present day it is abundant in France, and Fee states that the acorns of *Quercus suber* are of an agreeable flavor, and the hams of Bayonne are said to owe their high reputation from the pigs having fed on the acorns of the cork-tree. Some ancient authors speak of the cork-tree as the female of the holm-oak (*Quercus ilex*), and in countries where the holm does not grow, they used to substitute the wood of the cork-tree.

Traditional Origin of Social Distinctions.—In the latter part of the fourteenth century social distinctions became the subject of theological controversy in England—the Lollards, a religious association including large numbers of the common people, maintaining the natural equality of man; while the Roman Catholic preachers, on the other hand, encouraged the belief that the division of society into distinct classes was a permanent judgment of God, the origin of which, according to Alexander Barclay, a poetical writer in the reign of Henry VII., they thus accounted for: "One day, while Adam was absent occupied with his agricultural labors, Eve sat at home on their threshold with all her children about her, when suddenly she became aware of the approach of the Creator, and ashamed of the great number of them, and fearful that her productiveness might be misinterpreted, she hurriedly concealed those which were the least well-favored; 'some of them she placed under hay, some under straw and chaff, some in the chimney, and some in a tub of draff; but such as were fair and well made she wisely and cunningly kept with her.' God told her that he had come to see her children that he might promote them in their different degrees, upon which she presented them in the order of their birth. God then ordained the eldest to be an emperor, the second to be a king, and the third a duke to guide an army; of the rest he made earls, lords, barons, squires, knights, and hardy champions; some he appointed to be 'judges, mayors, and governors, merchants, sheriffs and protectors, aldermen and burgesses.' While all this was going on, Eve began to think of her other children, and unwilling that they should lose their share of honors, she now produced them from their hiding-places. They appeared, with their hair rough and powdered with chaff, some full of straws, and some covered with cobwebs and dust, 'that anybody might be frightened at the sight of them.' They were black with dirt, ill-favored in countenance, and misshapen in stature, and God did not conceal his disgust. 'None,' he said, 'can make a vessel of silver out of an earthen pitcher or goodly silk out of a goat's fleece, or a bright sword of a cow's tail; neither will I, though I can, make a noble gentleman out of a vile villain. You shall all be plowmen and tillers of the ground, to keep oxen and hogs, to dig and delve, and hedge and dike, and in this wise shall ye live in endless servitude. Even the townsmen shall laugh you to scorn; yet some of you shall be allowed to dwell in cities, and shall be admitted to such occupations as those of makers of puddings, butchers, cobblers, tinkers, costard-mongers, hostlers, or daubers.'" Such, the teller of the story informs us, was gravely taught as the beginning of servile labor.

Experiments in Punishment.—The present convict system of England is an outgrowth of the transportation system, which it has supplanted. It has grown up by successive alterations and improvements, made in accordance with varying circumstances and demands; and, to understand it fully, it is necessary to know something of the various experiments which have from time to time been tried with different methods of punishment. But, without going into this part of the subject, we give below the conclusions of a writer in the "Nineteenth Century" regarding the principles which experience seems to have established. They are: "1. That a well-devised system of secondary punishment should provide for subjecting those sentenced to it to a uniform course of penal deterrent discipline. 2. That every means possible should be adopted for developing and working on the higher feelings of the prisoners directly by moral, religious, and secular instruction, and indirectly by insuring industry, good conduct, and discipline, through appealing to the hope of advantage or reward, as well as by the fear of punishment. 3. That, with a view to deterrence as well as reformation, it is desirable that the first part of every sentence should be undergone on the separate system, as developed at Pentonville. 4. That, before discharging the convict to a full or modified degree of liberty, he should be subjected to further training, in which he should be associated under supervision, while at labor, but separated at all other times. 5. That properly constructed prison-buildings, providing among other things for this separation, are all-important requisites for the success of the system. 6. That employment should be provided, and industry enforced or encouraged for all. 7. That care should be taken to select and train a good staff of skilled and responsible officials to supervise and carry on the work of the convict establishments, and means adopted to prevent their work being hindered or defeated by the prisoners being brought into close contact, on works or otherwise, with free men who were under no such responsibilities. 8. That those who on discharge are disposed to follow honest courses should be guided and assisted in their endeavors, and that a careful watch should be kept over all till they have reëstablished their character."

Anthropometric Observation.—The report of the Anthropometric Committee of the British Association showed that considerable progress was made during the past year in the matter of collecting valuable statistical information. Returns had been obtained, giving the birthplace, origin, and sex, age, height and weight, strength of arm, and eyesight, of pupils at sundry public schools, London policemen and letter-sorters, workmen, rifle volunteers, soldiers, and criminals. By this means the committee were put in possession of nearly 12,000 original observations on the main question of weight and height in relation to age, in addition to 50,000 already collected. The committee submitted a series of tables made up from the information contained in the returns. From these it was shown that the London letter-sorters were the lowest in height, the average heights between the ages of twenty and thirty-five being 64 to 67·1 inches. The letter-sorters were also at the bottom of the weight table, their average weights in pounds being 122·5 to 139·9. The metropolitan police were at the head of both lists: height 69·2 to 71·5 inches and weight 122·5 to 182·7 pounds. Other tables were given, showing that the average height and weight vary with the social position and occupation of the people, and that to obtain the typical proportions of the British race it would be necessary to measure a certain number of individuals of each class. Taking the census of 1871, they find that a model community—that is, a community which would exhibit the typical proportions of the British race—must consist of 14·82 per cent. of the non-laboring class, 47·46 per cent. of the laboring class, and 37·72 per cent. of the artisan and operative class. It is found that the full stature is reached in the professional class at twenty-one years, and in the artisan class between twenty-five and thirty years. The growth in weight does not cease with that of the stature, but continues slowly in both classes up to the thirtieth year.

NOTES.

"Nature" records the death of Mr. Henry Negretti at the age of sixty-two years. He was the well-known optician, and the inventor of the deep-sea thermometer which bears his name.

On the authority of a fish-dealer at Sackett's Harbor, Mr. Seth Green states that shad in considerable numbers, and from two to four pounds' weight, were caught in the nets set for whitefish near Sackett's Harbor, in Lake Ontario, last summer. He thinks the fish have never visited salt-water, but are landlocked, and may form a permanent addition to the fauna of the lake. If this is confirmed, we have in it an interesting example of the adaptation of an organism to new conditions, the shad being a salt-water fish, frequenting fresh-water only at the spawning-season. It will also be interesting to observe the extent of the modifications likely to follow such a change of habit.

Languishing scientific organizations and lukewarm members of the same have, in the career of the Portland (Maine) Natural History Society, an example that should awaken their interest and arouse their activity. This society was incorporated in 1850, has been burned out several times, losing almost everything; but has nevertheless maintained its organization, and, largely through the interest and personal effort of Mr. C. B. Fuller, present curator of its museum, a very creditable collection of natural history objects has been got together again. Last winter the society purchased a site and have since erected a twelve-thousand-dollar building on it, which will, when all completed, furnish ample accommodations.

The public will be interested to know that there are signs of renewed activity on the part of the trustees of the Lick Observatory fund. Mr. S. W. Burnham, the observer of double stars, spent the month of August on Mount Hamilton with his telescope, in order to test this site for the proposed observatory. He reports the atmospheric conditions excellent, and it is hoped that this favorable result will lead to a new interest in the project.

The death of Dr. Eduard Fenzl, of Vienna, at the age of seventy-two years, is announced. He was Professor of Botany and Director of the Imperial Botanical Cabinet, a member of the Vienna Academy of Sciences, and Vice-President of the Vienna Horticultural Society.

In a recent pamphlet on the history of language, Dr. Samuel Wilks aims to prove that, in its larger sense, language has its basis in the lower animals. As to the parrot's faculty of acquiring the power of speech, his observations show that "it has a vocal apparatus of a most perfect kind, that it can gather through its ear the most delicate intonations of the human voice, that it can imitate these perfectly by continued labor, and finally hold them in the memory; also, that it associates these words with certain persons who have uttered them; also, that it can invent sounds corresponding to those which have emanated from certain objects."

Professor Nordenskjöld has announced his intention of starting soon on another journey of exploration to the Siberian Polar Sea. He will make the New Siberian Islands, visited in 1809–'10 by Hedenstroem, his base of operations.

The Russian monthly review, "Svet," announces a translation of Spencer's "Data of Ethics," to be published in its successive issues. As Spencer is a great favorite in Russia, the translation is being widely advertised, and a large demand for the numbers containing it is anticipated.

In 1877 twenty-two hundred persons were injured by passing vehicles in the streets of London, most of the accidents occurring at crossings in crowded thoroughfares. In 1878 the number of such accidents rose to thirty-three hundred, or an increase of one third. On account of this large increase, measures for the further protection of pedestrians at dangerous crossings were proposed in the House of Lords, but were objected to on constitutional grounds, and subsequently withdrawn. The recent narrow escape from being run over, of a prominent official and former Lord Mayor of London, has again called attention to the danger, and now the city authorities are about to take the matter in hand.

A striking example of the effect of bad conditions in increasing the fatality of epidemics is afforded by the recent outbreak of measles on the Island of Cape Clear, at the southern extremity of Ireland. This island is some three or four miles from the mainland, and contains between five and six hundred inhabitants, who live in small, low, dark, poorly-ventilated cabins, and pick up a scanty subsistence by farming and fishing. The contagion was introduced by a young girl, returning to her home from the mainland, where measles were prevalent. Of the first forty cases reported sixteen died, a mortality of forty per cent. This enormous death-rate arrested the attention of their neighbors on the mainland, and measures were at once taken for their relief. A temporary hospital with adequate sanitary provisions was established, and with this, aided by a corps of good nurses, they expected soon to arrest the epidemic.

BENJAMIN SILLIMAN.

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THE ORIGIN OF CRIMINAL LAW.

By WILLIAM W. BILLSON.

ANTERIOR to all regulations for the punishment or suppression of wrongs by an exercise of public authority, there was, as is generally agreed, a time when injuries found redress only through the resentment and retaliation of the injured party or his kin.

The progress of society from this rude sort of vindictive justice toward approved systems of criminal law presents some suggestive examples of the devious paths through which early communities were led to the recognition of truths which to us appear elementary. Nor is the history of this progress less intelligible or instructive to the general reader than to the professional student of the law; since it derives its interest not from its professional bearings, but from the interesting illustration which it affords of general methods of institutional development. In order to secure an accurate conception of the legal system, the early growth of which it is proposed to examine, it may be well to premise that the criminal law, which with a substantial uniformity of cardinal ideas now prevails in all civilized states, is well defined as "that branch of juridical law treating of those wrongs which the government notices as injurious to the public, and punishes by what is called a criminal proceeding, in its own name."

If it is desired to ascertain the point at which public authority began to supersede private revenge in the punishment of wrong-doers, it is worthy of observation that instances abound of tribes among whom the only offenses punishable by public authority are treason and its cognates, such as cowardice and desertion. Such was at one time the condition of the old German nations, and a similar paucity of recognized crimes is still discoverable among many of the Polynesian and American Indian tribes, and is indeed quite characteristic of uncivilized races. On the other hand, probably no instance can be cited where public authority has been exercised in the punishment of other offenses prior to its employment against those of a treasonable nature.

Indeed, we can scarcely imagine a phase of society so primitive but that treason if committed would be so punished. The traitor deals his blow not at a particular individual but equally at every member of his community, each of whom is therefore impelled to retaliation by the same natural impulse to which he responds in avenging a personal injury. Consultation and combination among the members of the betrayed community, with a view to revenge, are then as much a matter of course as in the case of an ordinary private injury they are among the family of the injured party. But, if proceeded against only by virtue of this general sense of personal injury, treason would still be destitute of the characteristics of a true crime. It may be said with perfect accuracy that every criminal law has for its object either to preserve the existence of government or to secure the adequate discharge of its functions. Many acts involving no moral delinquency are declared crimes. Others of an immoral nature are not. The one thing that can be said without exception of every crime is this: that it is supposed to militate against either the existence or the functional efficiency of government. Given a government and a recognized governmental function, and a resort to penal sanctions in their aid must always have been an obvious necessity. The tardy growth of criminal law is to be ascribed not to a failure of primitive societies to perceive this, but to their ignorance of what the true functions of government are. That which invested treasonable offenses with the character of true crimes before other species of wrong-doing had attained that dignity was the circumstance, now well attested, that after the family and *gens* the earliest governmental organizations were offensive or defensive military confederations, entered into with sole reference to organic movement against common external foes, and not with a view to internal or police regulations. That this was so no further evidence is required than to consider on the one hand how obvious and universal an expedient, even among savages, military confederation is, and on the other by what slow and unsteady steps and circuitous paths early societies have, as will be hereafter shown, found it necessary to advance toward the conception and inauguration of a general administration of justice. The institution of governments for military purposes involved the immediate rise of those branches of criminal jurisprudence which have for their objects respectively to preserve the government and to secure the efficient discharge of its military function. There are many of the American Indian tribes among whom the exercise of public authority for the protection of the person or property of individuals from injury is unknown, who yet in times of war organize a temporary government by the election of a military chieftain whose powers within their limited sphere are absolute, and are rigorously exercised in the punishment of treason, cowardice, desertion, and military insubordination or inefficiency. This is the extent of their criminal law.

Acts of violence by one person upon the person or property of another are not punishable, since the suppression of such acts is not among the purposes for which such a government is organized. But, for the treasonable or military offenses of which they do take notice, penalties are imposed upon the true theory of criminal jurisprudence, to uphold the government or to aid its efficiency.

It is, therefore, in this class of offenses that criminal law must have had an early but meager origin under the military confederations to which the most primitive societies intuitively resort.

It might be supposed that communities thus familiarized with the punishment of crime by public authority would rapidly develop a criminal jurisprudence by the simple and direct process of adding from time to time new crimes, perhaps in the order of their supposed enormity, to their catalogue of offenses. There are some tribes so circumstanced as at first glance to countenance this view—tribes, for instance, which, while not taking cognizance of ordinary offenses, are known occasionally to prosecute notoriously hardened or habitual offenders against the persons or property of their fellows: the murderers of general favorites, obnoxious medicine-men, or persons guilty of grossly impious or sacrilegious acts, or acts involving the people in intertribal controversies.

But it will be observed that in none of these cases does the concerted action against the offenders proceed upon the notion that it is the function of government to protect its citizens against crime. It is induced in each case simply by a widely prevailing feeling of personal resentment or fear. The murderer of the popular favorite falls a victim not to any theory of government, but to the sense of individual injury and loss shared in common by all the members of the community. The habitual offender is pursued in some such spirit as that in which we shoot down a pirate; not as a violator of law, but as an acknowledged enemy of all mankind. The medicine-man, the sacrilegist, and the offender against neighboring tribes, fall victims to the terror they inspire, the one by his reputed affinity with the powers of darkness; the second by his provoking, as is supposed, an indiscriminate visitation of divine wrath; the third by subjecting all his fellows to the hostility of adjacent tribes. They are not so much punished as sacrificed: the first two to avert the wrath of Heaven; the third to appease the offended tribes. These sporadic and personally revengeful or propitiatory punishments throw little if any light on the development of the law of crimes. They are not an essential part of that movement—the most important, interesting, and difficult in the history of criminal jurisprudence—by which society abandoned its original assumption that acts of violence or fraud between individuals are purely private grievances to be redressed by private remedies, and charged government with the function of protecting its citizens from such wrongs through proceedings conducted and punishments administered in its own name. The secret of that movement and the influence by which its progress was shaped can be gathered only from study of the antecedent practice of private retaliation. For both by its weakness and its strength the old system exercised a controlling influence over the development of the new. It was at once the chief inducement to the change and the chief obstacle to its accomplishment. In so far as public authority assumes by penal remedies to protect individuals from the criminal acts of one another, it was first called into existence, not by ordinary wrong-doing, but by an effort to restrain the abuses and excesses of retaliation as a remedial system. Its subsequent extension so as to displace the avenger and assume the punishment of wrong-doers generally was an afterthought. Thus the movement had its origin in a desire rather to mitigate punishments than to insure or increase them.

That this was true in the history of the Germanic tribes was long ago pointed out by Montesquieu with characteristic learning and ingenuity in his "Spirit of the Laws." He regarded it, however, as an experience peculiar to the Germans: to use his own language, "as contrary to the practice of all other nations." In this he was mistaken. The Germanic line of progress in criminal law, as it was pointed out by Montesquieu, instead of being unique, is substantially that which must have been pursued by all primitive communities with possibly rare and insignificant exceptions. Not only is this proposition justified by an examination of the actual processes of legal development among all races presenting the materials requisite for such an inquiry, but an analysis of the inducing causes among the Germans of this phase in their legal development will show them to have been such as were universally prevalent among mankind, and such as must have operated with remarkable uniformity.

It is to the illustration of these propositions that this paper will be mainly devoted. So far was the practice of private retaliation from being a preservative against crime, that it universally propagated more violence than it restrained. Under the most favorable circumstances, its punishments, being administered without an authoritative proceeding for the ascertainment of guilt, must frequently have fallen upon those who either were in fact, or by their relatives were thought to be, innocent. From this single infirmity of the system there must have arisen great numbers of bloody feuds, each having a tendency to propagate itself through generations. It also appears that, even in cases of acknowledged guilt, it was the custom in some communities for the family of an offender to protect him against the avenger, and to resent an attack upon him as an original injury. A family feud must then have inevitably ensued from every wrongful act of violence.

Even where the system had so far matured that the right of retaliation against a willful wrong-doer was recognized by his own family, revenge (as among the Israelites) was frequently taken on account of accidental or self-defensive acts of violence. It was a matter of course that the legitimacy of such revenge should be denied, and its exercise resented by the family upon which it was wreaked.

Again, the injured family in most instances claimed a right of revenge not only against the offending individual, but, in his absence, against any member of his family—a claim which was naturally and uniformly denied and resisted. In some societies the avenger seems to have thought it incumbent on him not only to take life for life, but to take two or more for one. Among the Congo people, according to Tuckey, if one be killed by an inferior, his family proceed to put all the male relatives of the guilty party to death. The prostitution of the practice is complete where, as among the Bushmen described by Reade, in his "Savage Africa," the stain of an injury suffered may be washed out by spilling the blood of any innocent third person, in case the guilty party is unknown or inaccessible. Superstition has occasionally operated as an additional irritant to an insane revenge. Schoolcraft relates that among some of the Dakota tribes of Indians each clan supposed the others to have supernatural powers whereby they could cause death. They hence frequently retaliated for deaths which they imagined to have been thus occasioned, though they were really due to natural causes.

From such diversities of view concerning the right of retaliation, and the justice of its application in particular instances, there inevitably ensued high carnivals of bloodshed and embroilment. While differing widely in degree among different races, the social disorder thus occasioned everywhere stood out in conspicuous contrast with that dearth of ordinary criminal acts which is characteristic of nearly all uncivilized tribes. Apart from the violence proceeding from blood-feuds, the unfrequency among such tribes of most of the acts we consider criminal is very noteworthy. The great mass of offenses, whether against person or property, which disgrace and disfigure civilization, are the product of evil passions engendered by the exasperating inequalities of condition which are unknown to the experience of uncivilized races. Of the instances of general and extreme addiction to crime which are occasionally found in the lower tribes of mankind, a few, perhaps, must be classed as exceptions to this rule, but most of them are to be explained by the fact that the races so characterized are not really primitive, but are suffering, probably in an aggravated form, from the vices of a civilization which they formerly enjoyed, or with which they have at some time come in contact.

The inducements to crime in a primitive community are too weak and public opinion is too strong to admit of the rapid growth of criminal practices. Offenses against property necessarily partake of the scantiness of property itself. If, however, through the prevalence of an especially quarrelsome disposition in any tribe, altercations and murders increase in numbers, the far greater calamities of retaliation are aggravated in the same proportion, and, where one life is taken in original altercation, whole families and generations are consumed in retaliatory feuds.

Hence, wherever we catch glimpses of societies before they have commenced to administer a general criminal justice, we find them already busy in devising expedients for the amelioration of feuds. Tacitus, in enumerating the affairs of state transacted at the great feasts of the Germans, mentions first in the order of business "the reconcilement of enemies."

The large place occupied by blood-feuds in ancient Semitic societies and the dark shadow which they cast over social life have been vividly portrayed by Michaelis in his work on the Mosaic laws. The notoriously blightful prevalence of such feuds among the American Indians is such as to prepare us for Schoolcraft's account of a tribe to the south of Lake Superior, which he found almost extinct through intestine feuds. Indeed, such instances are by no means uncommon. A passage in which Mr. Bellew describes the condition of the feud-ridden Berdurani, or northeastern Afghan tribes, so forcibly illustrates the demoralization ensuing from feuds as to justify its quotation at length: "Indeed," he says, "the quarrelsome character of this people and the constant strife that they lead are declared by a mere glance at their villages and fields, which bristle in all directions with round towers. These are constantly occupied by men at enmity with their neighbors in the same or adjoining villages, who, perched up in their little shooting-boxes, watch the opportunity of putting a bullet into each other's body with the most persevering patience. The fields, even, are studded with these round towers, and the men holding them most jealously guard their lands from any one with whom they are at feud. Nothing belonging to their enemies is safe from their vengeance. If even a fowl strays from its owner into the grounds of another, it is sure to receive a bullet from the adversary's tower. So constant are their feuds that it is a well-known fact that the village children are taught never to walk in the center of the road, but always from force of early habit walk stealthily along under cover of the wall nearest to any tower." These, it must be conceded, are extreme cases; yet they are a perfectly logical outgrowth of unaided and unhampered private retaliation. If most nations have outgrown the system without suffering so extreme wretchedness from its prevalence among them, it is to be ascribed to the promptness and ingenuity with which they have applied themselves to its modification. Instead of being, as has been considered, a necessary though rude expedient of primitive communities for the suppression of crime, it was from the beginning and under all circumstances preëminent in its fruitfulness of violence and disorder. It is more than doubtful whether it was either conceived or maintained with a view to the discouragement of crime. It had its origin in natural feelings of resentment, and afterward became a matter of honor. But, though vicious in its operation, the system had become so deeply rooted in the habits, the passions, the pride, the sense of honor, and the almost religious convictions of mankind, as to be among the most obstinate of institutions. Thus, among the Israelites, even after the Mosaic dispensation, the avenger was by public opinion so obligated to retaliation that in the words of Michaelis "the neglect thereof drew after it the greatest possible infamy, and subjected the man who avenged not the death of his relative to unceasing reproaches of cowardice or avarice." Among the Arabs, in the language of the same author, the avengement of blood constitutes "the prevailing point of honor among the whole nation"; and the acceptance of pecuniary compensation is, notwithstanding its recommendation by the Koran, considered vulgar. Writing of the Swedes, Geiger says—and his words apply with equal force to nearly all the early German nations—"Revenge for blood was a sacred obligation. It was at once the dearest heritage and the condition of every other, for in the olden time, if the father lay slain, the son could not inherit until he had avenged him." The old Salic laws likewise so linked the feuds of the family with its inheritances that a renunciation of the one worked an incapacity for the other. The loss of reputation which among the American Indians and other existing barbarians is universally incurred by failure to avenge blood is a matter of general notoriety. The difficulty experienced in some modern States in suppressing the duel is a faint illustration of the incorrigibility of blood-avengement; it being borne in mind that the modern code of honor is the conventionality of one class of society, while the old principle of retaliation rested on a universal passion and inflamed all classes alike, and that, while the modern duelist can forego his personal remedies, assured of the advantage of a matured system of law, the avenger was obliged to choose between his vengeance and a pecuniary composition, with the third alternative, in some instances, of a crude and inefficient judicial proceeding.

When King Alfred, outstripping the age in which he lived, and probably inspired by the example of Moses, denounced against willful murderers the punishment of death, his law was a dead-letter, and remained unexecuted during his own reign and those of several of his successors. The people preferred to redress their own grievances. Even long after pecuniary compositions for felonies had been abandoned, the laws of England continuing to provide two concurrent methods of prosecution for murder, one by indictment in the name of the king, and the other by appeal of felony at the suit of the kindred of the deceased, the latter was so confessedly the more favored remedy that, lest it might be barred by an acquittal under an indictment, no indictment was tried until after the expiration of the year and a day within which an appeal of felony might be instituted. This remained the practice until third Henry VII., when, in order to avoid these delays, it was enacted that acquittal on trial of an indictment should be no bar to an appeal of felony for the same offense. In the legislation of some countries, the conflict with reference to blood-avengement between the dictates of public policy on the one hand and the prevalent passions and notions of honor on the other was productive of a laughable incongruity. The law of Gottland, while making express provision for the appearance of the wrong-doer in court under safeguard, in order that he might offer the prosecutor a price in atonement of his offense, at the same time declared the prosecutor who accepted it at the first offer, even after the expiration of a year, to be a shameless person.

The tenacity with which the avenger adhered to his right of redress and the difficulty of controlling him in the exercise of this right are further attested by the character of the expedients by which it was sought to fortify measures aiming at his restraint. Thus Moses, though the Israelites were in his day quite familiar with the public prosecution of crimes, some of which were entirely withdrawn from the domain of private retaliation, found it still necessary to recognize the blood-avenger's right personally to pursue and slay without form of law the willful murderer: "The avenger of the blood shall slay the murderer; when he meeteth him he shall slay him."

But, as under most primitive codes of honor, so among the early Israelites the principle of blood-avengement was so malignant as to require retaliation even against the involuntary man-slayer. The instrument of death, whether man or beast, the avenger was in honor equally bound to destroy, without reference to the malicious or accidental character of the homicidal act. The flagrant injustice of punishing with death involuntary acts void of moral guilt, was in the Mosaic age, probably as manifest to large numbers of the Israelites as to Moses himself; yet so deeply rooted was the practice in the traditions of the people that the great law-giver dismissed as impracticable the idea of abolishing it. His scheme for ameliorating the hardships of both the willful murderer and the involuntary homicide by the designation of cities of refuge within the limits or vicinity of which they could find protection from the avenger, the former until he should have opportunity to prove his innocence, and the latter until the occurrence of some event with which his final discharge from liability could be plausibly linked, bears witness upon its face to the difficulty he anticipated in its enforcement. That his plan might be fortified by religious reverence and sacred associations, he provided for the selection of the cities of refuge from among the cities of the Levites, and dated the freedom of the excusable homicide from the death of the high priest. It is likely that among all early races the right of sanctuary has derived its strength from the considerations lying at the root of these Mosaic regulations. For although the absolute exclusion of violence from sacred precincts may have been originally suggested by religious sentiment, the widespread and tenacious application of the principle to criminal refugees must be mainly ascribed to the necessity so widely experienced of interposing obstacles to the avenger of blood; as is perhaps indicated by the circumstance that, as the exercise of avengement has been superseded by public prosecutions, the right of sanctuary has almost uniformly fallen into disrepute. Analogous in origin and aim to the right of sanctuary are the customs quite various and widely prevailing by which avengement has been prohibited during certain sacred seasons or occasions. Among the Swedes, for example, the Church contributed, as described by Geijer, to the abolition of blood-feuds by declaring all holidays and periods of some length at the great festivals consecrated to peace; and, ultimately, by throwing a similar protection over the sowing and harvest times. The Frisian was not to be molested by the avenger while going to or returning from church. There are some tribes of American Indians with whom all crimes except murder are buried in oblivion by the yearly sacrifice; so that the mention of them, or of any occurrence which brings them into recollection, is forbidden. If a Kenisteno chief wishes to settle any difference between his people, he announces his intention of opening his medicine-bag and smoking in his "sacred stem"; and no man who entertains a grudge against any of the party there assembled can smoke with the sacred stem.

The tenacity with which men clung to their right of personal retaliation can not be too strongly emphasized. When, by the demoralizing prevalence of feuds, society was first awakened to the necessity for taking measures to mitigate or suppress them, it is undoubtedly true that even if there had been a general willingness to abandon private revenge in favor of public prosecutions, the men of that period were incapable of either conceiving or executing so comprehensive a remedial scheme.

On the contrary, without any thought of the ultimate displacement of their revenge, they sought by various devices only to mitigate its excesses. But that displacement was made doubly difficult and the movement by which it was accomplished was in its details controlled by the stubbornness with which, even after comprehending the possibility of the new system, the people insisted upon adhering to their rights under the old. If further evidence or illustration of these truths is desired, it can be abundantly gathered from the sketch which it is now proposed to give of some of the steps by which societies, in their efforts to control the avenger and regulate avengement, were slowly and at first unconsciously led toward the cardinal doctrine of criminal jurisprudence, that it is the function of government to protect by suitable penalties its citizens in person and property from the violence and fraud of one another. "In order that revenge might not continually generate new revenge," says the historian of the Swedes, "the law essayed its earliest exercise of authority in reconcilement." At a time when murder was a purely private wrong, of which government took no cognizance, and the right of retaliation was thought too sacred for government to deny, the public interested itself only by discouraging revenge through the agency of public opinion, and by inviting and recommending pecuniary compositions with wrong-doers at rates which were usually fixed by law or custom, without, however, assuming to coerce either party into a settlement. Under such circumstances, if the avenger accepted the sum fixed by law as the price of composition, and afterward also took his revenge, this, as Montesquieu says, referring to the law of the Lombards, contained a public as well as a private offense; was a contempt of the law itself—a crime which the legislators never failed to punish. Later, the law, in order to avert feuds, declared it a crime to refuse to offer or accept pecuniary composition for murder. Government, while it had not yet undertaken to prevent or punish ordinary murders or larcenies, had been driven to apply itself to the suppression of feuds; and the withholding or rejection of composition money tending to defeat its efficient discharge of that function had the properties of a true crime, and was promptly recognized and punished as such. That pecuniary compositions for bloodshed were everywhere first made obligatory, rather to avert feuds than to punish wrong-doers, is attested by a great variety of circumstances. For instance, in fixing the amount to be paid in composition, the chief and usually the sole question or criterion seems to have been, What sum will offer to the avenger a sufficient inducement to forego his revenge? Rotharis, in the law of the Lombards, declares that he had increased the compositions anciently accustomed for wounds, to the end that, the wounded person being satisfied, all enmities should cease. Upon the same principle is to be explained the well-known tendency of early laws to adjust their penalties with principal regard to the aggrieved person's probable degree of exasperation at the time of detecting the wrong-doer.

The law of the Allemans, which, while undertaking to enforce compositions for stale offenses, conceded to injured parties the privilege of righting themselves on the spot and in the first transport of passion, finds a counterpart in the curious and yet under the circumstances perfectly natural distinction made in the Twelve Tables between manifest and non-manifest theft. Persons detected in the act of stealing, or with the booty in their possession, were liable to the punishment of death if slaves, and, if freemen, became thereby the bondmen of the owner of the property; while, if detected under other circumstances, they were only obligated to refund double the value of the stolen property. The marked incongruity, from a modern standpoint, of these two punishments was supposed by Montesquieu to have originated in Lacedæmonian theories of theft, and to have been handed down from ages when the crime of stealing was a small matter compared with the blunder of being found out. In other words, that the real crime consisted in being detected, and that hence, the longer detection was postponed and the more effectually the booty was disposed of or concealed, the lighter was the penalty imposed. Whatever may be said of the accuracy of this explanation, its ingenuity can not be denied.

On the other hand, Sir Henry Maine traces the widely discrepant penalties under consideration to a tendency, on the part of early administrators of justice, to "simulate" the probable acts of persons engaged in a private quarrel. "It is curious to observe," he says, "how completely the men of primitive times were persuaded that the impulses of the injured person were the proper measure of the vengeance he was entitled to exact, and how literally they imitated the probable rise and fall of his passions in fixing the scale of punishment."

Viewing these provisions of the Roman code in connection with other primitive laws, there can be no doubt that their scale of penalties was graduated, not with reference to the vengeance the injured party should be "entitled to exact," but with reference to the least amount of punishment by which, under given circumstances, he could probably be appeased. Pecuniary compositions for bloodshed, prevailing, as they presumably have, at some period in the history of every race, can not indeed be accounted for on any theory of punishment. They were conceived and established for purposes of pacification, apart from considerations of punishment or discipline. Blood for blood is an instinct of human nature; it is the justice which among every race was meted out with unsparing hand by the kindred of the slain when the burden and privilege of redress were upon them, and again by the state when she assumed the punishment of crimes. Pecuniary compositions prevailed only in the enforced absence of truly primitive remedies during that transition period when government was too wise to countenance the avenger, and not wise enough, or too feeble, to administer penal justice. It must be admitted that compulsory compositions, after they had superseded the practice of retaliation, came ultimately to be maintained with a view largely to the punishment and prevention of wrong-doing, and by a kind of inertia were carried over into periods capable of sustaining a true criminal law and already in the partial enjoyment of it. Even then, however, they proceeded upon our theory of damages against tort feasors. They were never at any time entitled to a place in the law of crimes. Returning from our digression, it is to be remarked that the adoption by the state of regulations for the control of parties at feud necessitated public prosecutions and punishments in order to insure their observance. One of the earliest methods of mitigating feuds was to allow the relatives of the wrong-doer to withdraw themselves from his feud on condition that they should entirely abandon him. If, after taking advantage of this law, they gave the wrong-doer assistance, they not only forfeited the protection which the law guaranteed them, and so were involved in the feud, but they so obviously sinned against the dignity of the state and its law that they were finable to the king. Such was the law of King Edmund of England. So, if, after the law had guaranteed the relatives of the culprit immunity from the feud in consideration of their abandonment of him, the injured party still took revenge on them, all his property was forfeited, and he was declared to be an enemy to the king and all his friends. In like manner, government in some instances undertook to give legal force to customs, many of which occur among our Indian tribes, which sought to discourage feuds by limiting the time within which revenge could be taken, or to restrictions upon the mode or measure of redress suggested by considerations of humanity. Although Mohammed, in the Koran, adheres to the law of personal retaliation for bloodshed, he counsels forgiveness or composition on the part of the aggrieved persons. But, against the person who, after receiving composition money as contemplated by his law, still proceeds to take his revenge, he denounces a "grievous punishment." The process of enforcing these and other limitations upon parties at feud resulted in developing and illustrating the idea of regulating by criminal laws the conduct of citizens toward one another, and thereby paved the way for the subsequent more general application of the same principle. There was another class of measures which tended to the same end by serving especially to mature a judicial machinery, and to familiarize the people with its operation. Next to its total abolition, the most effective remedy for the evils of blood-avengement was to forbid its exercise until the accused person should have had an opportunity to submit the question of his guilt to investigation in court. Under such circumstances a court was not a bar of justice at which accused persons were arraigned, but a place of refuge to which they fled. The Israelites had under the Mosaic laws in one respect passed this stage of development, since the public had undertaken to execute judgment against offenders when the avenger so desired. Yet an accused person only became entitled to a hearing in court after reaching a city of refuge, up to which time the avenger was at liberty to take his own redress without legal intervention. Having arrived at the city of refuge, the fugitive was entitled to have the question of his guilt investigated. If found guilty, he was either delivered into the hands of the avenger, or at the option of the latter was publicly executed, the prosecuting witnesses casting the first stones. That among the Germans, also, the first entertainment by courts of criminal charges was in the interest of the accused, is, as already remarked, settled beyond controversy by Montesquieu. Additional and curious illustration of the fact is afforded by the Swedish law, which not only threw the protection of the court around the accused while he negotiated with the adverse party for composition, but in case of the rejection of his reasonable overtures restored him to liberty with the right to carry full arms, and to defend himself against his enemies as well as he could. The custom very widely prevailing, by which a party found guilty of crime is delivered by the court to the prosecutor, to be executed or otherwise disposed of at his pleasure, is obviously an outgrowth and incident of the original protective function of courts, and wherever found is indicative of the former prevalence of that kind of judicial interference. This may be said to be the universal method of execution among such of the barbarous tribes as have attained to any judicial investigations at all. The same is generally true of Mohammedan countries.

Even in England, until as late as Henry IV., it was the custom in appeals of felony for the appellor and his kindred to drag the convicted appellee to the place of execution.

For the time employed in the trial, and the protection afforded by it, a reasonable compensation, called *Fredum* by the Germans, was usually paid by the accused to the judge or king. Under the Koran this debt of gratitude took a peculiar form. In order to compound for murder it was necessary not only to satisfy the family of the deceased, but also to ransom a brother Moslem from captivity. It is not difficult to understand how impositions of this sort, exacted at first for time consumed and protection afforded by the state for the accused, might readily adapt themselves to and even assist in the development of criminal law, by gradually assuming the character of fines for the offenses charged. Another line of progress of importance in some societies consisted in a gradual enlargement of the classes of offenses in which the king or state was supposed to have such an immediate interest as to justify a claim to a part of the composition money. Thus an injury to the person or property of any of the king's household, retainers, officers, or agents, was early construed to be an injury to himself. So, likewise, with wrongs committed against the guests of the king or persons of a household by whom he was entertained; or violence committed in the immediate presence of the king or in his castle, and afterward in the city or province where he was residing; or under other circumstances which, within the slowly expanding ideas on the subject, could be construed as involving an offense against the king's peace or dignity. It is an observation of M. Say that, in every branch of knowledge, example has preceded precept. So it was in the early history of criminal law. To a very great extent it was practiced before its theory was conceived or its first principle formulated. It was only after its judicial machinery had been developed by such random or diverse considerations, and for such special purposes as those heretofore enumerated, and after the people were thereby familiarized with its employment in favor of or against many classes of wrong-doers, that the practicability and propriety of its application to offenders generally were first perceived.

SAPORTA'S WORLD OF PLANTS BEFORE THE APPEARANCE OF MAN.*

Translated from the French by Miss E. A. YOUMANS.

MEN of science, whose patient researches have accumulated the proofs of the theory of evolution, have perhaps found more facts in support of this great philosophical doctrine in the vegetable than in the animal world. When we say the vegetable world, we of course mean chiefly fossil vegetables. It is only by the study of extinct forms, and their comparison with the living flora, that the affinities between actual types and distant ancestors have been discovered, and their mode of evolution revealed. Vegetable paleontology, it is true, is yet in its infancy, and has many great gaps; still, the rapidity with which it is being developed, and the prodigious number of facts that have been already collected, give good ground for the hope that the day is not far distant when we shall have surely determined the ancestral lines of most of our plants. To this the efforts of paleontologists are tending, and their activity is beyond all praise. During the last twenty years their discoveries have furnished the matter for large volumes and for many memoirs, published in the reports of academies of science, in the bulletins of geological societies, etc. But the profound lessons derived from these discoveries have hitherto been almost the exclusive possession of scientific men. People of general intelligence, who are interested in all progress have known little of the results obtained. This injustice could be no longer tolerated. A complete treatise was required, written in a style that all could comprehend, and summing up the progress thus far accomplished; and M. de Saporta, one of the most eminent authorities in vegetable paleontology, has just published such a work.

He devotes his first chapter to the theory of evolution, passing successively in review the most important arguments in its favor. Notwithstanding the great interest of this subject, it will not detain us now, for we wish to examine the main body of the work. Besides, Saporta is now writing for the "International Scientific Series" a book devoted to the study of evolution in the vegetable kingdom, where he will show the line of descent of the great families of plants.

* The World of Plants before the Appearance of Man. By Count de Saporta, Correspondent of the Institute. 8vo. 416 pages, with Thirteen Plates, of which five are colored, and One Hundred and Eighteen Figures in the Text. Paris: G. Masson. 1879.

The study of fossil flora not only enables us to follow the evolution of plants from their remotest known ancestors to their present actual descendants, but it throws much light upon the past mysteries of the earth, and especially upon the climatic conditions which controlled its surface while the slow revolutions of organic life were going on. We know what numerous causes concur to form a climate; latitude and longitude, the direction of winds and of currents of water, the nature and relief of the soil, and the distance from the sea. All these causes have their respective known effects, and have acted in the past as they act now; yet we know that, if it were needful to determine the amount of influence due to each of these agencies in the different geological epochs, we could not do it; the difficulties are too great. But in one case, that of latitude, we can find out its ancient effects by analogy with what is passing under our eyes, and by abstracting all other influences. We know that the obliquity of the sun's rays increases with latitude, and that temperature diminishes in the same proportion; that the higher the latitude of a region the less heat has its climate. But we know also that vegetation marches with temperature, provided always that soil and moisture are favorable. The floras of the temperate and polar regions show clearly the decrease of temperature from the equator to the pole. There exists between a flora and the climate in which it lives a relation so close that, knowing the one, we can represent the other. Palms do not grow in Greenland nor fir-trees on the plains of equatorial Africa. Each climate has its flora, and each flora its climate.

Paleontology has established the permanence and universality of this law; but it has at the same time established a singular fact which remains inexplicable. It is this: the different climates of the earth have not always been what they are now, either as to temperature or distribution. We speak only of those epochs which have succeeded each other since the time of the most ancient known plants. If we transport ourselves in thought to a time toward the end of the Tertiary period, and then, leaving behind us the Quaternary epoch, follow the course of the ages, we find, as an increasing enlargement of the tropical zone, that which is equivalent to an increase of temperature for the whole earth. More extended in the Pliocene epoch than in our day, this zone was still greater in the Miocene epoch, and yet greater in the Eocene, and so on till we reach a time when it embraced the whole surface of the earth, bestowing everywhere an equal temperature, feebly oscillating between certain limits. This climatic equality, which, according to Saporta, reaches at least as far back as the time of the coal, would probably cease at the epoch of the inferior chalk. Such is the fact established by examination of the flora of different ages.

Let us proceed to details. The Quaternary epoch, contrary to the opinion of the majority of geologists, was not, in France, and probably also in other countries, a period of universal cold. The term glacial which has been applied to it is certainly appropriate, because of the enormous and unknown extension of the glaciers, the traces of which are the principal character of the epoch. But at certain distances from existing glaciers there doubtless existed valleys with a

Fig. 1.—Ideal View of the Banks of Lake Aix at the Time of the Formation of the Gypsum.

warm or at least a temperate climate. The mixed fauna and flora of this period abundantly prove this. The remains of huge animals gathered in the ancient alluvium of the Seine and Somme, as determined by MM. Larted and Gaudry, demonstrate that many species indicating a very cold climate are found associated with those of a diametrically opposite character. Besides the mammoth, we encounter the ancient elephant, approaching that of India; the hippopotamus of African rivers peopled the waters of the Seine; while the hyena of the Cape frequented the meridian of France. The study of the forest flora, of which we find numerous remains in the contemporaneous tufa, leads to the same results; the vine, the laurel, the ivy, are found in abundance, not only in our southern regions, but also at Moret, near Paris. We find there also the much tenderer laurel of the Canaries. The northern trees of the same epoch were pines, lindens, maples, and oaks.

All these facts prove that the quaternary animals and plants characteristic of a cold climate existed only in the neighborhood of glaciers; and that, close by, in the valleys, lived creatures whose presence indicated a climate softer and more humid than ours. The mean annual heat necessary to their existence would be, at least, 14° or 15° centigrade. But, if we place ourselves now in the full Pliocene period, say near Lyons, we encounter the same vegetables, with others of a more southern character. At this epoch, in fact, the laurel-rose flourished on the banks of the Saône in company with the laurel, the *avocatier* of the Canaries, the bamboo, the magnolia, and the evergreen oak. The well-known climatic needs of these species warrant us in assigning to the country a mean annual temperature of 17° or 18° centigrade, and, as the actual mean temperature of Lyons is only 11°, we can judge of the difference of temperature which separates our epoch from that of the Pliocene. Moreover, as Saporta remarks, the figures which express the climate of Lyons during the Pliocene epoch are not only higher than those which apply to the neighborhood of Marseilles in Quaternary time, but, in place of corresponding to the 43° of latitude, these higher figures coincide with the 46°. They mark a progression of heat corresponding with latitude, the effect of which is to raise the temperature of northern regions in proportion as we bury ourselves in the past.

These curious phenomena appear still more evident and more general, if we transport ourselves in thought to the Miocene epoch. The entire unbroken documents abound in the boreal hemisphere, and we can there exactly determine the climates of all latitudes from 40° to 80°. Admirably preserved fossil plants, brought from the polar regions by different travelers, show that glaciers have not always desolated the pole. One of the principal deposits of these vegetables was found on the western side of Greenland at Atanekerdluk in 70° of latitude in the adjacent island of Noursoak. On the steep sides of a ravine one thousand feet deep, there exist entire beds of petrified leaves and other *débris* imbedded in a very ferruginous rock. The vast accumulation of leaves is truly surprising—trunks yet in place; flowers, fruit, insects accompanying them. M. Heer, who has studied these precious remains, says that here arose a vast forest where abounded sequoias, poplars, oaks, magnolias, ebony, holly, walnut, and a host of other species. Still farther north, at 80° of latitude, were found aquatic

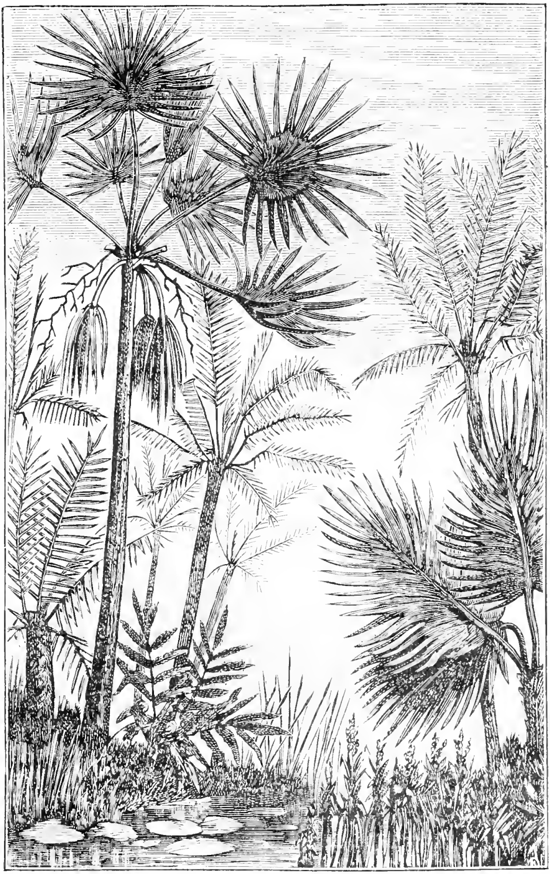

Fig. 2.—Principal Palms and Cycadeæ of the Middle Tertiary in Europe.

plants, pond-weed, water-lilies, rushes, etc., and terrestrial plants—bald cypress, thyme, fir, plane, linden, maple, mountain-ash, and even magnolias, forming a grand forest. The illustrious Professor of Zurich, M. Heer, regards many of these plants as miocene, and concludes that if these latitudes at this time were disposed as they are now—that is, if the earth's axis has not been displaced—all the earth received more heat, and the line of the tropics must have risen toward the north. The difference of the Miocene period may be valued at 25° or 30° of latitude—that is, we must at present descend 40° or 45° to find the temperature which then existed in Greenland.

The study of the more ancient floras brings new proof of this phenomenon of the extension of heat into the higher latitudes, and conducts us finally to that equality of climate of which we have spoken. "We are forced to conclude, however," remarks Saporta, "that when we reach the time of the coal and the most remote period in the history of organic beings, if there has been no change in the relations of the heat that falls upon our globe, there have doubtless been other changes profound enough to impress upon it a very different aspect from that which it has since presented, and to create conditions of existence about which we can form no idea." We are, in fact, ignorant of the conditions in which living beings first made their appearance and were developed. There have been many hypotheses about it, but the facts on which they rest are yet neither sufficiently numerous nor convincing. For the settlement of this question we must await the future.

As to the cause of climatic equality over all the earth in the Primary and Secondary epochs, we are equally in the dark. All the explanations that have been given have been successively rejected. The displacement of the axis of the earth, the inclination of that axis on the orbit of our planet, the precession of the equinoxes, etc., are some of the hypotheses put forth on this subject. We can not here enumerate them all; but there is one on which Saporta insists, not because it explains everything, but because it agrees more or less with the celebrated cosmogony of Laplace, and accords with the phenomena of the primitive world as revealed by science. This hypothesis was put forth some years ago by M. Blaudet. We know that, according to the theory of Laplace, the entire solar system was originally an immense nebula which has since condensed little by little, and successively given off rings of cosmical matter which have become planets. The central star is hence more and more reduced, has become more dense, more luminous and more ardent, until it has attained the dimensions and properties of our actual sun. In other words, if we could trace backward the course of the ages, we should find the sun progressively augmenting in volume, but its heat and light would diminish in intensity in the same proportion. We do not know what sun lighted the earth when life first appeared upon it, but, from the theory of Laplace, we may suppose that it was much larger than ours.

Such conditions, however, would explain many phenomena. This great sun, occupying a good part of the horizon, would give a twilight so luminous and so prolonged as perhaps to annul the night. Sending his perpendicular rays much farther from the equator than now, the torrid zone would be thus enlarged. The calmer light, the more gentle and equalized heat, the thicker and more humid atmosphere, explain that equalization of temperature, those days half veiled and transparent nights, and that tepid climate of the polar regions, that we might consider as presiding at the development of primitive life. Finally, the primitive sun, by its slow condensation, passing insensibly into its present state, necessarily forced the retreat of the torrid zone, thus ending the anterior equality of the climate, permitting cold to become established at the pole, and concentrating heat at the equator. Such is the bold but attractive hypothesis of M. Blaudet. No doubt it leaves many points obscure, but the numerous partisans of the theory of Laplace will not hesitate to acknowledge its importance, for, in reality, it is part of the theory itself.

It remains now to review the remarkable chapter that Saporta has given to the study of vegetable periods. We may remark at the outset that this word "period" implies no such general convulsions as the first geologists believed in, who supposed the history of the globe broken into sharp periods, each of which was inaugurated by a distinct creation and terminated by a sudden and universal destruction. Saporta takes care to warn us against this error. "Nature, always active," says he, "has had no intermittence nor time of sleep. Life, since its first appearance, has not ceased to inhabit the earth. Depressed sometimes, interrupted never, there has circulated without respite a constantly fertile sap. The epochs and revolutions which geologists have named are valuable only as serving to introduce great dividing lines in the bosom of an incalculable duration, but a closer view reveals these beings always succeeding each other; the extinction of some among them would not prevent survivors from occupying their place. Physical revolutions, essentially accidental and unequal, have never been radically destructive. If some periods have been less favorable than others to the development of life, these relatively impoverished intervals have possessed organized beings that, afterward multiplying and diversifying, have easily repeopled the globe."

Saporta divides the world of fossil vegetables into four great periods: 1. The Primordial or *eophytic*, corresponding to the Laurentian, Cambrian, and Silurian; 2. The Carboniferous or *paleophytic*, comprehending the Devonian, Carboniferous, and Permian; 3. The Secondary period or *mesophytic*, commencing with the Trias and reaching to the end of the chloritic chalk; 4. Finally, the Tertiary or *neophytic*, embracing all the formations from the chalk of Rouen up to and including the Pliocene.

The flora of the eophytic period is unknown. The *débris* which represents it has in general a character so vague that there is yet no agreement upon its true nature. The graphite found in the Laurentian indicates, however, that from this epoch vegetables existed in great abundance. In the Cambrian and Silurian, fossils are found that are differently interpreted, and in which at present some think they see algæ. The famous bilobites, so abundant at the base of the Silurian, appear also to have been algæ of very great height. Finally, certain marine plants, as those that are represented by Fig. 3, are connected with a type of algæ so marked that it is difficult to mistake them.

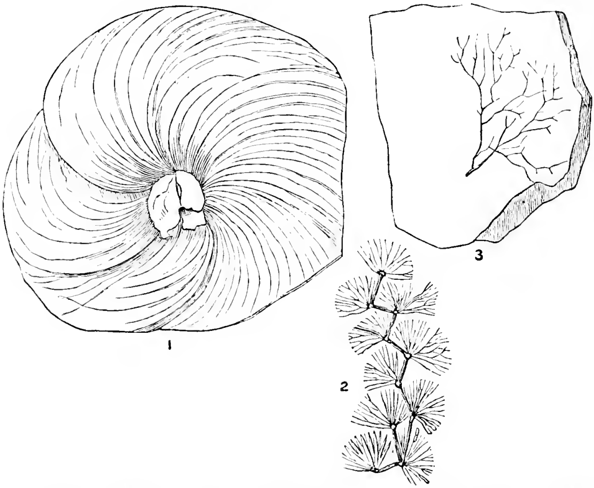

FIG. 3.—PRIMORDIAL MARINE PLANTS: 1. *Spyrophyton* of Hall (Silurian of America). 2. *Murchisonites Forbesi* (Goepp) (Silurian of Ireland). 3. *Chondrites fruticulosus* (Goepp).

Many of these plants are undeniably linked with more modern types, of which they bear the generic form, and prove that this primordial flora is not really separated from that which followed it. We can even affirm that certain Silurian algæ have had a duration so prodigious and a tenacity of character so pronounced that their last direct descendants were living in the European seas in the middle of Tertiary time. As to primordial land-plants they are excessively rare, and those that we have gathered seem to demonstrate that in the Silurian epoch to which they belong the vegetable forms represented types that we encounter in subsequent formations, and that are characteristic. In Fig. 4 are shown those that M. Lesquereux observed in the Upper Silurian of the United States. Among them are the *Psilophyton*, which disappeared with the Devonian, and the ambiguous characters of which approached at the same time the ferns by the Hymenophyles, the Lycopodiaceæ by Psilotum, and the Rhizocarpes by Pilularia.

With the Devonian things changed. The bad state of preservation of fossil vegetables belonging to this formation has not permitted us to study them perfectly; but, from the aspect of those which we possess, we conclude that at this epoch the vegetable kingdom was already vigorous and varied, and that nature while in its infancy put forth the carboniferous flora, the almost inconceivable exuberance of

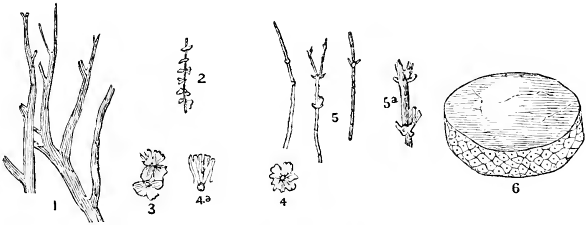

Fig. 4.—Primordial Terrestrial Plants observed by M. Lesquereux in the Upper Silurian of America: 1. *Psilophyton cornutum* (Lesquereux). 2-4. *Sphenophyllum primosis*. 5. *Annularia Romingeri*. 6. *Protostigma sigillarioïdes*.

which has never since been equaled. This flora, to the description of which numerous works have been devoted, is still more interesting and important as furnishing the elements of the coal—the soul of industry, as it has so justly been called. We know that the conditions in which the coal-beds were formed very much resembled those in the midst of which the peat is now actually being formed. As Saporta has observed, in the Carboniferous epoch there were emersions upon a grand scale, emersions succeeding each other, flowing over and receding from the insular or continental space, until its recovery from the waters. This action of the waters would produce a low bank or shore around the primitive land, the relief of which would tend to become more accented, and at length would retain the waters coming from the interior and unite them at the bottom of extensive depressions. In this way were formed vast lakes, with vague banks and shallow waters, easily invaded by plants loving an aquatic station. If we join to this the humid warmth, the thickness of the atmosphere, charged with vapors, causing frequent and violent rains, we perceive how favorable were the conditions for the development of the carboniferous vegetation.

The plants of this flora belong exclusively to the two classes of vascular cryptogams and gymnospermous phanerogams. At the head of the cryptogams were the Calamarias, which recall on a gigantic scale the Equisetaceæ of our day; by their side Asteraceæ, Annularia, Sphenophyles; then come ferns of very varied form and structure, and Licopodiaceæ of the type Lepidendroideæ. Certain plants, the Bornia, Calamodendreæ, and Sigillaria, form connecting links between cryptogams and phanerogams. These were gymnosperms, that is, plants assimilable by the class *Cycadeæ* to the conifers and the actual Gnetaceæ. The true phanerogams, the angiosperms, appeared much later. Further, the carboniferous flora comprehended some Cycadeæ, such as the *Noeggerathia foliosa*, and a pterophyllum discovered recently by M. Grand' Eury; some true conifers, as the Walchia; some Taxineæ more or less like our Ginkgo; and, finally, a great number of Cordaïticæ, most of which were great trees so perfectly preserved that they could not only be placed at the head of the gymnosperms, but their affinities with the class of angiosperms could also be observed.

The Permian flora, which succeeded the Carboniferous, is only a pale reflection of it. The characteristic type of the preceding age has disappeared, while the others, the Cycadeæ, the conifers (Fig. 5), and the Taxineæ, tend to preponderate. The Permian is an epoch of transition, having ambiguous characters. The constituent elements of the coming vegetation were being developed. Saporta says of the Trias, which commences the Secondary or mesophytic period, that "it appears to correspond to one of those periods of revival where the

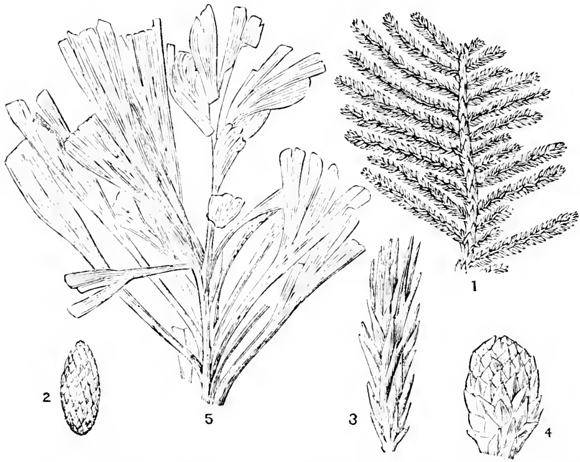

FIG. 5.—CHARACTERISTIC PERMIAN PLANTS: CONIFERS. 1, 2. *Walchia piniformis* (Stroub)—1, branch; 2, detached cone. 3, 4. *Ulmannia frumentaria* (Goepp)—3. branch; 4, strobile. 5. *Ginkgophyllum Grassetti*—Sap, branch, leaves (Permian Schist of Lodove and Herault).

failing types finally disappear, while those which displace them are successively introduced. The first leave chasms because they are reduced to a decreasing number of individuals; the last are yet obscure and rare. Both old and young are equally feeble, and, when these two extremes meet, the apparel of nature seems poor and monotonous."

At the beginning of the Jurassic period a transformation is already manifest, and we soon find ourselves in the presence of a new flora, where the carboniferous types have disappeared, but where, except some rare monocotyledons, the angiosperms are still wanting. Always cryptogams and gymnosperms, the first represented by ferns and Equesitaceæ, the second by Cycadeæ and conifers. From Spitzbergen to Hindostan, from Europe to Siberia, everywhere the same vegetable forms, so that the character of the Jurassic flora is monotonous, lifeless, and relatively indigent. However, we quickly perceive two sorts of vegetation: one peculiar to low and humid plains, including beautiful ferns and Cycadeæ (Fig. 6); and the other covering the hilly regions, and composed of different genera of the same families, but chiefly of tall conifers, which in great part composed the forests of that time.

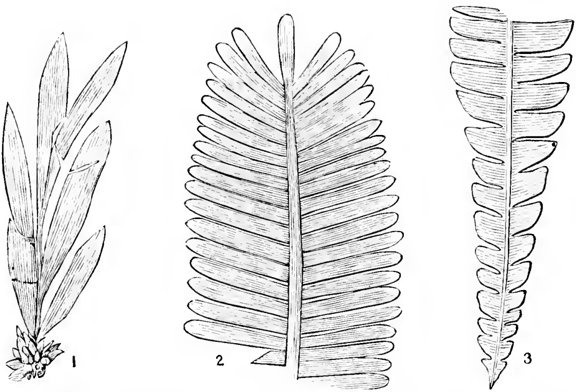

FIG. 6.—CHARACTERISTIC JURASSIC PLANTS: TYPES OF CYCADEÆ OF HUMID LOCALITIES: 1. *Podozamites distans* (Presl.); young plant. 2. *Pterophyllum Jaegeri* (Brongn.); summit of a leaf. 3. *Pterozamites comptus* (Schim.); interior part of a leaf.

We know not under the influence of what conditions organic evolution, and especially the appearance of dicotyledons, has taken place; but we do know that from the horizon of the cenomanne chalk commenced the neophytic period, these plants appear in a multitude of places and multiply with great rapidity. Wherever the cenomanien is found we find the remains of that age, proving the predominance of dicotyledons and the decrease of Cycadeæ and conifers. "This revolution," says Saporta, "has been as rapid in its progress as universal in its effects." It would certainly be interesting to follow the author in his enumeration of the ancestors of our common plants, and his description of the progenitors of the poplar, the beech, the ivy, the chestnut, the plane-tree and others, but it would extend this article beyond the limits of our space. Besides, we have followed vegetable evolution through its principal phases—that is to say, we have in some sort witnessed the successive appearance of different classes of plants, we have seen the rising and falling movements of vegetation, periods of activity alternating with periods of relative repose, and that succession, or better, that procession of phenomena which has enabled us, if not to comprehend, at least to prove the transformations of life that all together are called evolution.

We shall find analogous phenomena in the series of Tertiary time, to which Saporta has given his longest chapter. This part of his work contains many descriptions of plants. They show us more than the simple succession of flora. The growing differentiation of the divers types and the consequent multiplication of species conduct us insensibly to the actual vegetable world. We see the growth of local flora, some of which are so clearly defined that we are able, by the aid of the imagination and of some well-preserved fragments, to reconstruct the principal genera and species of which they were composed. Fig. 1 represents a group of these plants so restored. The numerous modifications undergone by the vegetable kingdom during the Tertiary age, the formation of local floras, etc., are easily explained if we recall what was before said, of the influence of the medium upon living beings, and especially upon plants, that can not escape. Climatic equality no longer exists. The European Continent, up to this time made up of islands, tends now to aggregate and take on its present form ; the soil

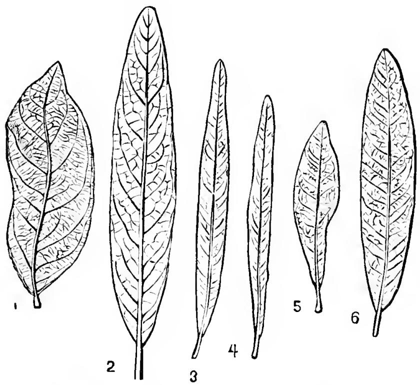

Fig. 7.—Homologous Forms of Paleocene and Eocene Oaks compared (Types of entire leaves): 1. *Quercus Lamberti* (Wat.) (Paleocene). 2. *Quercus tæniata* (Sap.) (Middle Eocene). 3. *Quercus macilenta* (Sap.) (Middle Eocene). 4. *Quercus paleophellos* (Sap.) (Upper Eocene). 5. *Quercus elliptica* (Upper Eocene). 6. *Quercus salicina* (Upper Eocene).

is subject to movements of oscillation, which often change the configuration and relief of various countries. Lakes of fresh water are formed, and then disappear. The nature of the soil varies as marine deposits recapture it from deposits of fresh water ; and reciprocally.

This instability of the environment has produced an instability of the flora, and caused those differences which have resulted in the European vegetation of our time.

As before remarked, in speaking of ancient climates, when we go back in time, and particularly Tertiary time, we see the vegetation taking more and more of a tropical character. Hence in these epochs there existed in Europe a multitude of forms which can not live there now. Palms and Cycadeæ (Fig. 2) and large, beautiful ferns were long ago exiled. Other forms, as the laurel, the vine, the ivy, have never quitted the region where they were born, or, at least, where they appeared for the first time.

The number of figures that Saporta has interspersed with his text, representing the principal vegetable types of the past, offer us the still further advantage of comparing species of the same type, and verifying by inspection the respective modifications of these species, and their passage from one to the other. Without doubt, we are far from possessing all the terms of all the series; but what we know of some enables us to judge by analogy that what has happened with one genus may happen with others. See, for example, the forms of Pliocene and Eocene oak (Fig. 7), which show clearly how climate has affected this species from the formation of Gelinden at the base of the Pliocene to the gypsum of Aix, that is, the superior Eocene. The forms repre-

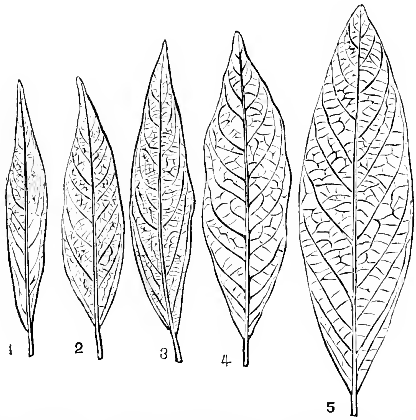

Fig. 8.—Successive Forms of the Laurel Type, showing the Passage from *Laurus primigenia* to *L. Canariensis*: 1–3. *Laurus primigenia*. 4. *L. princeps*. 5. *L. Canariensis*.

sented here belong to the group of oaks with entire leaves; but there is another group with leaves toothed or lobed, in which we discover analogous modifications. We see that leaves at first oval tend to become more and more slender, and these lanceolate forms express very truly the action of the warm, dry climate of the Eocene, which succeeded the warm but humid climate of the Pliocene.

Other striking examples of these affinities of species are furnished by the laurel type (Fig. 8) and that of the ivy (Fig. 9). The large

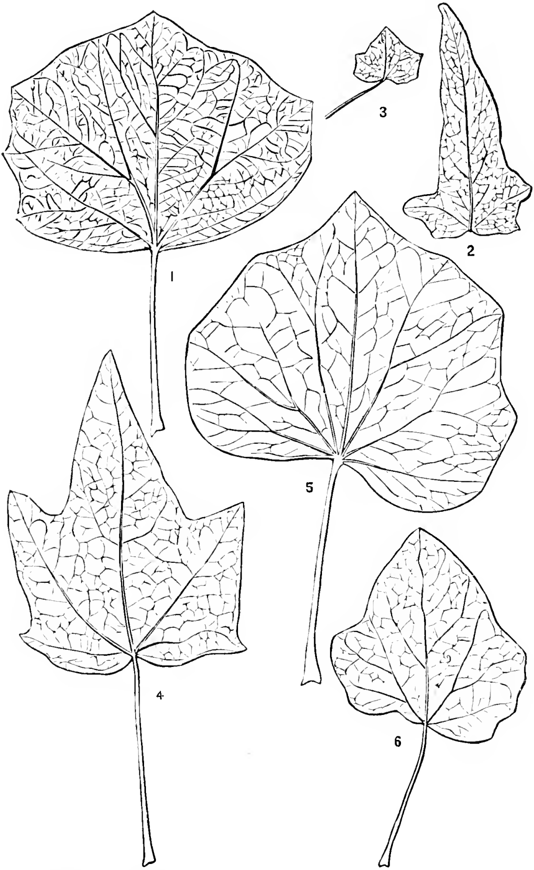

Fig. 9.—Successive Modifications of the Type *Hedera* in the Course of the Tertiary Epoch: 1. *Hedera prisca.* 2. *H. Philibertii.* 3. *H. Kargii.* 4. *H. Acutelobata.* 5. *H. MacCluri.* 6. *H. Strozzi.*

varieties of *Laurus primigenia* pass insensibly into *Laurus Canariensis.* "It seems," says M. de Saporta, "that the narrow forms of this same *Laurus primigenia*, which at the same time are the most ancient, mark the existence of a race-due to the Eocene climate. This influence is gradually lessened, as seen in the expansion of the leaf as we advance toward the Aquitanian, and in the Armissan at first, and Manosque afterward. The relation between the amplified leaves of the *Laurus primigenia* and those of *Laurus Canariensis* and *Laurus nobilis* is more and more pronounced. The *Laurus princeps* of the superior Miocene approaches still nearer to our laurel; while, finally, the Canarian race has all the characters of Meximieux in the inferior Pliocene.

As to the ivy, its most distant ancestor is a species of the cenomanienne chalk of Bohemia, the *Hedera primordialis*, whose large leaves bear witness to the moistness of the climate under which it lived. The Pliocene species, *Hedera prisca*, found at Sezanne, is sensibly removed from the preceding species by the salient angles of its leaves and its much smaller dimensions. The *Hedera Philibertii*, recently discovered in the gypsum of Aix by Professor Philiberti, testifies clearly, by its narrow and pointed form, to the influence of the Eocene climate. It recalls to our astonishment the most slender forms of the ivy of Algiers, and also the forms that the European ivy takes when it runs on the ground, so that these two races may well have had the *Hedera Philibertii* for their common point of departure. The *Hedera Kargii*, characterized by its very small leaves, seems to be derived from the *Hedera prisca*. The *Hedera acutelobata* scarcely differs from the actual species; in the same way the *Hedera Mac-Cluri* is confounded with the ivy of Ireland. Upon the whole, if we consider the varieties presented by our actual ivy we are tempted to believe that the ancient forms have only been races of the same species.

We must here close this analysis. Readers wishing a better knowledge of this important subject than we have been able to give must be referred to the work of M. de Saporta, which will be found as agreeable as it is instructive.—*Revue Scientifique.*

HOW TYPHOID FEVER IS CONVEYED.

BY DR. T. J. MACLAGAN.

TYPHOID fever is one of the most common of the serious ailments of civilized life. No household is safe against it; there is no family which it may not invade. In Great Britain alone not much short of 200,000 people suffer from it every year. Of these nearly 20,000 die, most of them in the prime of life. It is even more prevalent on the Continent.

The question of the contagiousness of such a disease is one of vital importance; and yet it is one on which the most antagonistic opinions are held.

Among the many ailments which may be transmitted from the sick to the healthy, the ones with which we are most familiar in this country are those which are grouped together under the name of "the eruptive fevers." To this group typhoid fever belongs. It includes also small-pox, typhus fever, scarlet fever, and measles. Each consists of an attack of fever of more or less definite duration, and of a local inflammation or eruption: during the course of each its poison is largely reproduced in the system; and each may be transmitted from the sick to the healthy.

There are several ways in which a disease may be transmitted:

1. Its poison may be introduced directly by inoculation, as is daily done in the case of vaccination.

2. It may pass directly into the surrounding atmosphere from the persons of the sick, and be inhaled by those in their neighborhood, as constantly happens in small-pox, typhus fever, measles, and scarlet fever.

3. It may be conveyed indirectly, and to a distance, in articles of clothing, bed-linen, etc., and, passing from them, may be inhaled by those who wear or handle them, as often happens in the same diseases. Or it may be conveyed in food or water, and enter the system through the digestive organs, as frequently happens with the poison of typhoid fever.

When we wish to say that a disease is transmitted from person to person, without defining the mode of transmission, we say that it is COMMUNICABLE. The term is a general one, which includes every mode of transmission.

When we wish to say that a disease may be transmitted by inoculation, we say that it is INOCULABLE.

When we wish to say that the poison may be conveyed in articles of clothing, in linen, in food, in water, etc., we say that these articles have been infected by the poison, and that the disease is INFECTIOUS.

When we wish to say that a disease is produced by personal contact with one suffering from it, and that the danger of catching it increases with the closeness and intimacy of such contact, we call it CONTAGIOUS.

A contagious disease, therefore, is one in which the danger of contracting it increases as we approach, and diminishes as we recede from, a person suffering from it. It is *contactuous*.

Contagion may be defined as direct infection; and infection as indirect contagion. In both a poison passes from the sick to the healthy. It is the difference in the mode of conveyance of the poison that makes the difference between the two. The distinction is one of the utmost practical importance, and must be borne in mind in discussing the question of the contagiousness of any disease. An ailment may be infectious without being contagious. When, with reference to a case of typhoid fever in his own house, a man asks the question, "Is it contagious?" he does not wish to know whether or not some one in the next street may take the disease, but whether or not there is a likelihood of its spreading among the members of his own household, and whether or not there is danger in going near the sufferer. The only accurate and proper meaning of the word is that attached to it in the definition which I have given. That, therefore, is the sense in which it is used in this paper.

What is the nature of the poisons which pass from the sick to the healthy? Their most distinctive peculiarity is, that they are largely reproduced in the system during the course of the maladies to which they give rise. The minutest possible portion of small-pox matter, for instance, may be introduced into the system of a person who has not had that disease, and who has not been vaccinated, with the certainty of giving rise to a malady during whose course there will be formed many thousand times as much of the poison as sufficed to set the disease agoing.

Contagion, then, consists physically of minute solid particles. The process of contagion is the passage of these from the bodies of the sick into the surrounding atmosphere, and in the inhalation of one or more of them by those in the immediate neighborhood. If contagion were a gaseous or vapory emanation, it would be equally diffused through the sick-room, and all who entered it would, if susceptible, suffer alike and inevitably. But such is not the case; for many people are exposed for weeks and months without suffering. Of two persons situated in exactly the same circumstances, and exposed in exactly the same degree to a given contagion, one may suffer and the other escape. The explanation of this is, that the little particles of contagion are irregularly scattered about in the atmosphere, so that the inhalation of one or more of them is purely a matter of chance, such chance bearing a direct relation to the number of particles which exist in a given cubic space. Suppose that a hundred germs are floating about in a room containing two thousand cubic feet of air. There is one germ for every twenty cubic feet. Naturally the germs will be most numerous in the immediate neighborhood of their source, the person of the sufferer; but, excepting this one place, they may be pretty equally distributed through the room; or they may be very unequally distributed. A draught across the bed may carry them now to one side, now to the other. The mass of them may be near the ceiling, or near the floor. In a given twenty cubic feet, there may be a dozen germs, or there may be none at all. One who enters the room may inhale a germ before he has been in it ten minutes; or he may remain there for an hour without doing so. Double the number of germs, and you double the danger. Diminish the size of the room by one half, and you do the same. Keep the windows shut, and you keep the germs in; open them, and they pass out with the changing air. Hence the importance of free ventilation; and hence one reason why fever should be treated, if possible, in large, airy rooms. Not only is free ventilation good for the sufferer, but it diminishes the risk to the attendants.

We see in this, too, the reason for banishing bed-curtains, carpets, and all unnecessary furniture from the sick-room in cases of contagious fever. The germs are apt to adhere to such articles, and so make them the means of conveying the disease to others.

All organisms consume in their growth nitrogen and water. Those with which we are now dealing are no exception to the rule. Growing in the system, they must get these elements there. But nitrogen and water are the chief materials required for the nutrition and repair of the various organs and tissues of the body. The propagation in it of millions of organisms, having wants identical in the main with those of its own tissues, must cause serious disturbance. And so it does. This disturbance declares itself by that aggregate of phenomena to which we apply the term fever.

An organism which thus grows in and at the expense of another is a parasite. One of the peculiarities of parasites is that they flourish, not in any part of their host, but only in some particular organ or tissue, which is called the *nidus*, or nest of the parasite. The organisms with which we are now dealing (the poisons of the eruptive fevers) show similar peculiarities. Each has its own nidus, its own localized habitat, in which it is propagated, and out of which it ceases to be reproduced. The poison of small-pox has its nidus in the deep layer of the skin; hence its characteristic eruption. That of scarlet fever in the superficial layer of the skin and in the throat; hence the rash and the sore-throat of that disease. That of measles in the skin and in the mucous membrane of the air-passages; hence its characteristic symptoms. That of typhoid fever in the glands of the intestine; hence that disease consists of fever and of ulceration of the bowel.

The contagiousness of a given eruptive fever must be directly as the number of germs which, in a given time, pass from the body of a sufferer into the surrounding atmosphere. This, in its turn, must depend on the seat of the propagation of the poison, and on the relation which this bears to that atmosphere. In small-pox, scarlet fever, typhus fever, and measles, the seat of this propagation is the skin and mucous membrane of the air-passages; it is, therefore, in direct, free, and constant communication with the external air. The poisons of these diseases are accordingly freely given off into the atmosphere of the room in which the sufferer is, and they themselves are highly contagious.

In typhoid fever, the poison is propagated in the bowel, and is thrown off with the discharges from it. It thus passes from the system in a manner and in a combination which insure its speedy removal from the neighborhood of the sufferer. The typhoid-germs are there;

but they are mingled with discharges which may be removed, and as matter of course are removed, before the germs can pass off from them into the surrounding atmosphere. The seat of the propagation of the typhoid-poison has no direct relation with this atmosphere; germs can not pass directly from the one to the other; the disease, therefore, does not display the property of contagiousness.

The danger in typhoid fever is not contact with the person of the sufferer, but contact with his stools. If these are properly managed and disposed of, the disease can scarcely spread. But, if they are allowed to pass into drains which are imperfectly trapped, inadequately ventilated, or insufficiently flushed, or if they are carelessly thrown on the ground, or allowed to percolate through the soil into drinking-water, then one case of typhoid fever may give rise to many others. The occurrence of a case of typhoid fever in a house is a sharp test of the efficiency of its sanitary arrangements. If these are perfect, and the stools properly managed, all will go well; if they are defective, one case may give rise to many others. But the communication of the disease is not direct, by contact; it is indirect, by infection of drinking-water, or of an atmosphere which may be remote from the person who is the source of the poison. A case of typhoid fever is introduced into a locality. The stools are thrown out on the ground or into a cesspool, whence they percolate through the soil into a well. The person who drinks water from that well runs a greater risk than one who sleeps in the same room as the sufferer and is in constant attendance on him.

The practical outcome of all this is—1. That the mother may nurse her son, the wife her husband, the sister her brother, without the risk involved in the case of typhus or scarlet fever; and, 2. That there is little or no danger to the other inmates of the house, if its sanitary arrangements are perfect and the stools properly managed.

On this view of the nature and mode of action of contagion, it is easy to see, not only how the process of contagion and its varying phenomena may be explained, but how, by care, much may be done both to prevent the poison from passing into the atmosphere and to diminish its chance of acting after it has got there. We have only to consider what is the chief channel by which the contagion gets exit from the system, to know by what means we are most likely to prevent its passing into the surrounding atmosphere. In typhoid fever the poison passes off in the stools; and what we have to do is to see that these are promptly and properly disinfected and disposed of. In small-pox, scarlet fever, typhus fever, and measles, it is eliminated by the skin, and we can not altogether prevent its getting into the atmosphere; but, by frequent sponging with some disinfecting fluid, or even with plain water, many germs may be arrested in their outward course.

The apostolic mode of anointing with oil is also an efficacious way of fixing and arresting the germs: it is specially useful during convalescence from scarlet fever in fixing the particles of peeling skin, which are a source of much danger. They are dangerous because they contain the germs which have been produced in them. What we see happen in the larger particles of skin happens also in many of the much smaller particles of contagion.

By the adoption of these various measures, by rigorously isolating the sufferer, and by having the room well ventilated, much, very much may be done to check the spread of contagious fevers. The matter of which organisms are composed is one of the most perishable things in nature. Contagion is no exception to the rule. By exposure to the air much of it is destroyed; hence such exposure is one of the best of all disinfectants.

Sanitary science has done much to show us how some of the diseases with which we are now dealing might be extinguished, and how all of them might have their prevalence greatly diminished. It rests with those who have such ailments in their houses to carry into effect the measures calculated to destroy and get rid of the poison, before it has had time or opportunity to be a source of danger to those around. But the adoption of proper measures presupposes a knowledge of the nature of the poison with which we have to deal, and of the manner in which it passes off from the system. In not one is this knowledge more necessary than in typhoid fever; in not one are the measures which such knowledge dictates more easily applied, or more likely to be effective. But, to regard typhoid fever as contagious in the sense that small-pox and typhus fever are so, is to divert attention from the true source of danger, to lead to the adoption of measures which are uncalled for, to the neglect of those which are urgently required; is to cause unnecessary concern to the sufferer and his friends, and to deprive him and them of the mutual comfort and solace which a little daily intercourse affords. The peculiarities of the illness may be such as to make it right to exclude the friends; but isolation is not requisite for the same reason that it is so in typhus.

One more point. The receiver as well as the giver of the poison has something to do with the determination of its action. Not every person into whose system a germ passes necessarily suffers from its action. A man who has had small-pox, for instance, is no longer susceptible to the action of its poison—and why? Not because the poison can not get into his system, for we can make sure of that by inoculating him with it, but because, during the first attack, the nidus, the special material necessary to its propagation, was exhausted, and has not been reproduced. This immunity from a second attack is a general characteristic of the eruptive fevers; individual exceptions there are, but the rule is that one attack confers immunity from a second.

A germ does not act unless it reaches its nidus; it may enter the system, make the round of the circulation, and again pass out without ever coming in contact with its nidus, and therefore without doing harm.

The more widely the nidus is diffused, the less likely is this to happen. In small-pox, in scarlet fever, and in measles, the nidus is widely scattered. In none of them is a germ likely to make the round of circulation more than two or three times, without being conveyed to its nidus.

In typhoid fever the nidus is situated in a limited portion of the bowel, the sole route to which, by way of the circulation, is through an artery the size of a crowquill ; a typhoid-germ may be taken in through the lungs, and may make the round of circulation two or three dozen times, without being likely to enter that particular vessel. The more often this may occur, the greater the chance of its being thrown off from the system without acting. But, if the typhoid-germ be taken in through the digestive organs, it is brought into direct contact with the seat of its nidus, and can scarcely fail to act. Hence the great danger of drinking water or milk contaminated with the typhoid-poison.

The glands which constitute this nidus are not equally prominent and active all through life. In infancy they are quite rudimentary. At two or three they begin to grow, and gradually increase in size, and presumably in functional activity, till the age of puberty. They continue to be very distinct for twenty or twenty-five years. After forty they begin to get less, and gradually diminish till at seventy they have dwindled away so much that they can no longer exercise any active function. Their period of prominence and of functional activity corresponds exactly to the period of susceptibility to the action of the poison of typhoid fever. That disease is extremely rare in infancy ; from two to six, or seven, it is more common, but is generally very mild. At fifteen or sixteen commences the period of greatest liability to it ; and from that age until thirty-five and forty it is very common and very fatal. After forty-five it begins to decline both in frequency and severity ; and goes on declining as years advance, till at seventy the liability to it may be regarded as practically worn out. When it occurs in advanced life it is generally mild ; but its occurrence then is as rare as in infancy. Increased and diminished susceptibility to the action of the poison of typhoid fever correspond exactly to the increase and diminution in the size and functional activity of the glands which constitute its nidus.

The insusceptibility to the action of the poison, which is naturally and slowly developed in old age, is artificially and rapidly produced by the destruction of the nidus during an attack of the disease.

Using the word contagious in its proper sense of communicable by contact, and regarding the typhoid-poison as a parasite whose nidus is in the glands of the bowel, we are led to the conclusion that the disease to which it gives rise, though undoubtedly infectious, can scarcely be contagious. We know from our experience that it is not so ; for it never spreads in hospitals, and attendants on the sick suffer no more than other people.

The difficulty has been to reconcile these facts with the reproduction of the poison in the system. The source of this difficulty is the rooted belief that this reproduction takes place in the blood. On this view all the eruptive fevers ought to be equally contagious. But let us once adopt the view that the poisons of the eruptive fevers are parasites, and that the seat of the local lesion of each is the nidus of its parasite, and therefore the seat of its propagation, and the whole difficulty vanishes. We at once see why each has a definite period of duration, why one attack protects against a second, why each has its own characteristic lesion, why each presents such varying degrees of severity, and why they possess different degrees of contagiousness. —*Abridged from the Nineteenth Century.*

HANOVERIAN VILLAGE LIFE.

By WALTER NORDHOFF.

THE Hanoverian village of E—— lies a few miles distant from a famous university town, in a district which still maintains many old-time customs, and which presents, therefore, a curious image of German rural life thirty or forty years ago.

The approach to E—— from G—— is very pretty. The thorough culture of German fields and the absence of fences make a rural prospect especially pleasing to an American. At the foot of a low hill, and completely embowered in green, lay E——, with nothing of it visible as we neared it except the church-steeple and the red-tiled roofs of the principal houses. My lodgings were in a house near the church ; my room—the best in the house—commanding a view and smell of the stable and barnyard, with its manure-heap, which we passed on our way from the street to the front door. I still wonder why in E—— the parlor, dining-room, and best sleeping-rooms are made to face the barnyard, while the kitchen and servants' rooms look out upon a pretty garden in which the family spends most of its summer days.

The commune or village of E—— has about six hundred inhabitants. It has no manufactures, and all its people, even its officials except the clergymen, live either partly or entirely upon the produce of the soil tilled by themselves. The tilled land is very minutely subdivided, the pasturage and forest-lands being held and used in common, while the laws and customs governing this use, and the general system of land tenure, culture, and improvement, are in many ways curious to an American.

The land belonging to the commune or village of E—— is divided into tillable, pasture, and wood land. The tilled land amounts to eleven hundred and forty acres, and is owned in plots of from thirty to fifty acres. The *Bauermeister*, or head of the village, owns one hundred and fifty acres, but he is exceptionally wealthy. The church-lands are two hundred and eighty acres, and there are also two hundred and ten acres owned by a noble family, non-resident. The tillable church-lands are let to factory and railroad laborers in small plots, and the women of these tenants form a part of the general laboring force in the harvest-season.

Twenty acres is the least amount of land that a peasant, who lives on the produce of his farm alone, can cultivate profitably in this region, and the living thus obtained is so miserable that those who own so little generally eke out their subsistence by renting land from richer farmers. Sixty acres of the land around E—— have been set apart, by old usage, as common, on which those of the villagers who own "village rights" graze their animals, and from which they get clay and stone for building and a certain amount of hay for winter use. The extreme subdivision of the land around E—— is the result of the laws which govern the inheritance of land in the province. At the death of the head of the family his land is divided equally among his children, his wife having first taken out of the estate the amount of money or land she brought her husband at marriage, and, in addition to this, a part equal to the share of one of the children. The mother's property at her death goes to the children in the same way.

Church-lands can be sold when the consent of the minister, church trustees, and church government has been obtained, but such sales rarely take place. Land belonging to the commune as commons can not be sold unless special authority has first been given by the state.

The highest value I heard set on any land in E—— was three hundred dollars an acre for a garden-spot in the village itself. Land near E—— is not worth so much as near some of the towns around it, because it has never been *verkoppelt* or "married," as the process is called, by means of which a peasant obtains one compact farm in exchange for a dozen or more widely scattered, small fields. This *Verkoppelung* and the laws and customs which make such a process necessary show so much of the German farmer's mode of life that I will explain the manner in which it is carried out: In accordance with the laws which govern inheritance, each daughter must receive either at her marriage or at the death of her parents a certain share, varying with the number of children, of all the land belonging to her parents. The chances are, of course, very much against the land which she thus inherits adjoining that of her husband, so that, in the first generation, the family have two fields which may be a mile or two apart. Now, when this couple die, each one of their children receives its share, not of the whole, but of each field owned by the parents. Suppose this process to go on for a century, and it will be readily understood that a peasant may own thirty or forty fields, each containing but a small fraction of an acre, and no two of which lie together. To remedy the evils of this system, Verkoppelung commissions were created for each province by the state, which also undertook the draining, irrigation, and laying out of roads through the land on which they worked.

Any landholder in a village may, by merely notifying the district magistrate, call a meeting of the farmers to consider whether the land of the village shall be verkoppelt, but, if less than half the landowners respond to the call, or if a majority are against the measure, the caller of the meeting has to pay its legal expenses. If half the landowners respond, and the question is favorably decided, notice is at once sent by the magistrate to the general Verkoppelung commission. This commission decides whether the village meeting did its work in a legal way, and, if the requisite amount of red tape proves to have been used, appoints an inferior commission to see that the roads, canals, and ditches are properly placed, and to be responsible for the honest performance of the work to be done. The first work of this commission is to register the value of the land owned by each farmer; then the land is ditched, and canals and roads are built. After the work is finished, all the land of the village is divided into a certain number of grades, generally eight, the first of which contains the best farming-land; the remainder containing continually poorer and poorer land until in the last are placed the mountain pasture-fields. Upon each one of these subdivisions a value is then set by the commission; the total value put upon the land being, of course, equal to the value of all the village land before the Verkoppelung. The commission then retires, and a farmers' meeting is called to ratify its valuation. If at this meeting any one objects to the value set upon any piece of land, his objection is noted and sent to the general commission, and, if thought to be reasonable, the land is valued anew; but, if the question is decided adversely to the objector, he has still the right to refuse to take the land in dispute, and it can not be forced upon him. If, however, a considerable number of objections are made to the valuation, a new inferior commission is appointed, this time from among the farmers who have objected to the former valuation; and the decision of this last commission is final, no appeal being allowed.

The preliminaries having been successfully adjusted, the general commission then allots to each farmer arbitrarily an amount of land equal in value, although perhaps not in quantity, to that he had before his land was taken. Whenever there is pasture-land among that belonging to the village, each farmer receives, after the Verkoppelung, a certain amount of it; in which case his farm lies in two parts. The average cost per acre of the whole process is about five dollars, and this is assessed on each peasant according to the value of the land he receives. In case any farmer can not pay his share of the expenses, his land is sold, just as it would be for unpaid taxes.

When a person has land to let, he sends notice to the town crier, who then parades the streets, beating a drum and stopping at each corner to announce that such a person has so much land which will be rented on such a day. On the day mentioned, all those interested meet in the public square, and a lawyer, or the village magistrate, states to the assembly the quantity and location, and the general terms on which it will be rented. He then auctions off the lot field by field. The highest price paid per acre per year, in E——, is seven dollars and fifty cents, and poor land rents as low as twelve cents a year. Leases run from six to eighteen years. Each renter of land deposits with the magistrate, at whose office his lease is drawn up, a sum of money equal to the rental of the land he has taken for one year, and in most cases for two years. The money thus deposited remains with the justice during the whole term for which the land is rented, and is then returned to the depositor if he has paid everything due the landowner. The amount of ready money thus required is so great that farmers can seldom afford to rent more than a few acres of land. Owing in part to the excessively high rent paid for land, and in part to this deposit, farmers can make little more than their living expenses from rented land. In fact, even those who own their land are glad to get through the year without having to run in debt or to deny themselves some of the necessaries of life.

Without exception, the methods of cultivation employed around E—— would be thought in this country old-fashioned and inefficient. Even such simple tools as the scythe and cradle are seldom used, almost all the grain being cut handful after handful with a sickle, and then carefully laid out to dry before being bound into small bundles. A whole family works day after day over the grain, handling each straw at least three times, and yet showing no trace of mental fatigue at the (to me) awful monotony of the work. I could only wonder at the temerity of a government which dares to educate a people before whom, from their childhood, lies nothing but the prospect of drudgery so constant and so stupefying. The farmers, to economize time, generally do their threshing at night, rising for this purpose at twelve or one o'clock, and working at it until it is time for their regular day's labor to begin.

Grains of different sorts and leguminous plants are the main crops grown around E——, to which each farmer adds whatever he needs for his own use. In most cases, also, they do a little market-gardening for the neighboring city market. According to the method by which all the land belonging to the community of E—— is cultivated, the whole arable soil of the village is divided without regard to private ownership into three parts, called Winter, Sommer, and Brachfeld, or fallow. In the Winterfeld are grown those crops which are planted in the fall, or early in the spring—being for E—— mainly rye and wheat. The Sommerfeld has the spring-sown crops, of which barley and oats are good examples. The Brachfeld is, as its name denotes, allowed to lie entirely fallow, or at most is used for pasture, or for the growth of such light crops as esparsette and the legumes. Next year the Brachfeld of the former year becomes Winterfeld ; the former Winterfeld is used for Sommerfeld ; and so on year after year, and century after century.

A part of the commune-land is used as pasture, and on it each person holding a village right may pasture a certain number of cattle, sheep, pigs, and geese. A second part is meadow-land, and every twelve years this is divided into as many parts as there are holders of village rights, and each one receives a share, of which he has the exclusive use until the redivision at the end of the duodecade. Still a third part of the commune-land is planted with fruit-trees ; the produce of which is sold for the benefit of the communal treasury. A fourth, and largest part, is planted with forest-trees, and from it each person receives yearly a certain amount of building and fire wood.

During the months when farm-work is possible the peasants in E—— rise between four and five, and, after a breakfast of coffee, sausage, and bread, go at once to the fields. At half-past nine or ten the whole family sit down in the field and eat black bread, washed down with a kind of coarse brandy called schnapps. Then work goes on again until twelve, when, if the day is hot, they return home and rest for an hour or two, making their noonday meal of bread and the remains of the coffee prepared in the morning and kept warm on the embers, or, if wood is scarce, by wrapping the coffee-pot in the bedclothes! After their return to work, an afternoon meal of bread and schnapps is eaten at half-past three, and an evening meal of bread, coffee, and a warm soup, when they stop work at seven or eight. Constant toil of this sort leaves but little time for reading or self-improvement, and only six papers are taken in E——, not more than twelve or fourteen persons in all reading them. These weeklies and a few story-books, loaned out by the pastor, are the only reading material of a village of five hundred and ninety-one souls. The bread eaten by the peasants is made of coarse black flour, baked once or at most twice a month, and eaten without butter. On Sunday morning a little beef or mutton is sometimes eaten by a few families, but otherwise no animal food is taken except in the form of sausage-meat. Children do not work in the fields until about ten years of age, nor is much work done by them for five or six years later, as from six to fifteen or sixteen years of age they are compelled to attend school. In summer, from June 24th to September 29th, there is no afternoon session of the school, and the children then help in the harvest. The toil of a peasant being so constant, is also done slowly and poorly. A wood-sawyer, for instance, holds and works his saw with only one hand, and draws a breath between each stroke.

A compulsory school law in the province of Hanover forces the peasants to study during ten years of their lives, and during this time a little reading, writing, and arithmetic is acquired; but beyond this is and a slight knowledge of High German they do not advance. Cleanliness is not a peasant virtue in this region, and perhaps I had better say nothing on the subject, further than that the pig is at all times a welcome member of the highest village society, and generally goes into the house by the front door.

All work and no play makes the peasant a dull fellow, and the little education he gets does not help him much. Many stories of their blunders are current, involving oftenest the local Dogberries. To this sort belongs the sign said to have been posted in a stable in G——, and which notified the stablemen that "it is forbidden to feed the horses or cows with lighted pipes or cigars." A trespass notice, still to be seen near E——, gives perhaps the best idea of this sort of muddle-headedness. Written in Plattdeutsch, it gives the warning: "This road is no road, but he who will travel it notwithstanding is fined four marks and two days in jail; the informer to receive half." Laws are so strict and well enforced that there are few crimes. Such as do occur in E—— are mainly fights caused by liquor and family quarrels, which the pastor commonly has influence enough to settle.

Owing to the small land-holdings there is in E—— no distinct class of what we in this country call farm-help; but, when a man has not money enough to hire land in the ordinary way, he goes to a farmer and asks for six or eight acres of land, agreeing to pay so much rent, and giving no deposit, but binding himself to work for the farmer at rates much below those usually paid day laborers—twenty-five cents a day or thirty-five cents for cutting an acre of grain being the prices paid to such boundmen.

House-servants are employed in E—— only by the minister. They are hired at Easter, or on the 16th of November, and one year is the usual length of the term for which they engage. Housemaids receive from fifteen to twenty-five dollars a year, and a present of twenty yards of linen and a pair of shoes; it is also customary to give them small money fees once or twice a year if they have done their work well.

I ought to have explained before, that the village, besides being a collection of people assembled together for protection and to afford church and school facilities, is also a commune in the sense that it is a closed corporation without the power of self-extension or contraction. The village can and does own property, and hires men to do village work, as, for instance, to take care of the cattle owned by members of the corporation. This system of land tenure is said to have originated in the following way: In the earliest times a single family held all the land around it in common. At that time all the land was divided, as it still is, into three parts, to provide for the alternation of crops and the resting of the land. Each man then received his share of the land for a year only, a redivision being made at the end of each season. As time went on, the term for which land was allotted increased, until gradually the principle of private property was introduced and the ownership of land became fixed. But this change did not affect pasture or forest land. The result of all this has been the retention of the communal idea in regard to the so-called village rights which belong to the *citizens* of E——, but not to all its inhabitants. There are only sixty-six of these *rights*, and this number can not be increased or diminished, so that only a small part of the six hundred inhabitants of E—— are citizens. Each one of the *rights* can be halved—thus, of course, also halving the privileges of the possessor, but the subdivision can go no further. Each *right* gives its possessor the privilege of grazing a certain number of sheep, cattle, geese, and swine on the public pasture; of mowing a certain amount of meadow-land, and of getting stone and clay for building from the village pits, besides a considerable amount of wood each year from the communal forest. Village *rights* have thus a considerable value, and are sold at prices ranging from two hundred and twenty-five to three hundred dollars each. In order to possess a *right* a man must own a house in the village, and he can not own more than one *right* unless he increases the number of houses he owns in the same proportion.

Since the number of *rights* can not be increased, and since each one can only be halved, there must, of course, be numbers of people in the village who are not corporators. Such persons have none of the privileges belonging to the rest except the permission to graze cattle on the common pasture when they have paid to the commune authorities a fixed price per head for each animal thus fed; nor have such persons any vote when communal affairs are to be passed upon.

E—— is entirely independent of the neighboring city of G——, but offenses against the law are tried by an inferior court sitting in the latter place. Each male in E—— who has attained the age of thirty years, and who is not a pauper or criminal, has a single vote in the election of those officers who are to govern his village. These officials are, first, a Bauermeister, having the combined powers of sheriff and town clerk; under him are two deputies and a Council of twelve men, all elected for a period of six years. The Bauermeister, who is generally one of the wealthiest and most intelligent of the citizens, keeps the village accounts; makes the state and military reports; registers births, marriages, and deaths, also sales and rentals of land; places criminals and insane in safe keeping; receives applications from the village poor; gives notice of the commencement of military service, to which each young man is bound; and reports to the state at specified times upon communal and village affairs. He is also President of the Council and of all village meetings. For all this hard work he receives only forty dollars a year, and his assistants get nothing but the barren honor of election. Over the Bauermeister is placed a state official who has control of a number of villages. Provincial and village taxes are collected by an officer elected for a term of six years, who receives about thirty dollars per annum for his services.

E—— has two foresters appointed by an imperial forester, under whose control they are. These officers receive about forty-five dollars a year, and for this sum must decide all matters in regard to the cutting or planting of trees ; must see that no wood is stolen, and during the wood-cutting season must prevent any one cutting more than his share, and see that only marked trees are cut. They must, moreover, preserve all the game in the forest for the use of that person to whom the right to kill game has been let.

The pastor of E—— is supported by the rental of two hundred and eighty acres of land, belonging to the church, and his income is also slightly increased by marriage, burial, and other fees. Since the minister is the only cultivated man in the village, he has of course great influence over all village affairs, and acts as peacemaker in all disputes or quarrels. To him each farmer comes as occasion demands for advice or instruction, but he never visits his people, except when severe illness or death calls for his good offices, nor have I ever seen a peasant enter the parsonage, except when called there by business. This total separation of the pastor from his flock seemed to me to make the church a mere formal affair incapable of doing much good, yet I could not wonder at the refusal of an educated man to associate with the peasants. Village ministers are appointed by the church consistory, and hold their places for life, unless they break some church rule or preach false doctrine. They are always university men, and are generally well-read, but their views are apt to be narrow—Darwin being looked upon as an arch-fiend, and science, in so far as it does not agree with literal translations of the Bible, as "science falsely so called." They revolve in a little circle, independently of all the secular world, around some bishop or church dignitary. Their social life consists of an interchange of afternoon and evening calls, at which coffee is drunk, and the world, the flesh, and the devil, discussed in a very innocent way ; occasionally this monotony is interrupted by a birthday party or a church celebration. The latter are, however, a delusion and a snare to outsiders, as each preacher goes with a sermon or two in his pocket and with his mind made up to read them. As a consequence of this, and of the German peasant's love for sermons, I once stood up in a crowded church from 7 A. M. to 5 P. M., with only an hour's intermission for dinner, listening to an endless series of sermons, varied only by a change of speakers ! I left the church at five, but was afterward told that there was an evening session and that the preaching went on for three days.

The pastor is president of a board of trustees, consisting of four church-members, by whom all church expenses are audited, and also of a school board, of four electors and the teacher, which controls school matters. The members of these boards, with the exception of the minister and teacher, are chosen for six years by the votes of all the male church-members.

The schoolmaster unites in one person the duties of sexton, grave-digger, and bell-ringer. All teachers must have passed an examination held by the state, for which they are prepared by some years' study at preparatory schools and a three years' course at one of the eight normal schools in Hanover. In order to enter these schools, the applicant must be eighteen years old and be able to pass an examination in the elementary studies. Teachers earn from one hundred and seventy-five to two hundred and twenty-five dollars a year. In E—— the teacher received eighty-seven cents a year from each of his one hundred pupils, fifteen dollars a year from the church for his services as sexton, besides fifty cents for each adult's and twenty-five cents for each child's grave dug by him. From the state he got eighty-two dollars, and from the village seven dollars and fifty cents a year, with six acres of good farming-land and a house. All the books and maps I saw were of the most old-fashioned sort, and the teacher was drunk whenever he had money enough to buy schnapps. The church consistory appoints and removes the village teachers throughout Hanover. Teachers are not considered socially equal to nor do they associate with ministers. With the teacher ends the list of village officers, and next come those communal servants for whom we in this country have no equivalent. In what follows, the distinction between village electors and commune citizens or corporators must be borne in mind. Those that I have called electors comprise all males over thirty who live in E——, while there are only sixty-six citizens of the commune. Electors have no rights except that of voting for village officers, while village corporators possess many valuable privileges, a list of which I have given above. Communal servants consist of a shepherd, a cowherd, who also looks after the swine, and a gooseherd, who, in addition, is town-crier, and runs on errands for the Bauermeister. All these men are elected yearly at a meeting of the corporators. Such places are much sought after, but do not descend from father to son. Each full corporator may send out daily with these herders four cows, six sheep without lambs, four pigs without shoats, and twelve geese. The animals are collected every morning at stated hours by the herders, who go through the streets playing peculiar airs on their horns, at the sound of which those corporators who wish to send their animals out turn them into the street to be collected. In the evening the animals are brought back from the pasture by their herders, and turned loose in the village to find their own way home. Sheep, however, are not returned to their owners each night in this way, but remain with the herder during the summer season. For their labor the herders receive very little ready money, most of their salary being paid in agricultural products. Each of the herders receives a house and a quarter of an acre of land from the commune. In addition, the shepherd has the privilege of pasturing fifty sheep of his own, and receives seven dollars and a half a year from the commune and about fifty dollars yearly in grain from the citizens. The cow-herder makes about forty dollars a year, and the goose-herder receives a hundred loaves of bread from the citizens and twenty-two dollars in money from the commune, for which he must do all the town-crying and go daily for the orders of the Bauermeister.

I could get very little information in regard to the modes of taxation of the village, each person being willing to tell me what taxes he paid but no one seeming to know just how they were assessed. A farmer with forty acres of land paid, the year I was in E——, five dollars as land-tax, three dollars as poll-tax, one dollar as house-tax, and four dollars as village-tax. He would also, if he had kept a shop or inn, have had to pay a special license. Incomes of less than one hundred and ten dollars are exempt from taxation. Ministers and teachers pay state but not village taxes. The pastor of E—— paid a tax of nine dollars on his income of four hundred and fifty dollars, and a land-tax of twenty-four dollars on two hundred acres of land. Communal taxes vary greatly in rate according to the wealth of the commune. Some communes, which own valuable mines or forests, not only exact no tax from their citizens, but divide annually a surplus among the corporators. A case of this sort is rare, but it is not uncommon to have most of the communal taxes paid by the sale of wood from commune forests.

Almshouse accommodations are so poor and the food and treatment so bad that but few of the inhabitants of E—— feel pauperism to be their vocation. Only one villager receives food and shelter from the village, and a second food alone. Their provisions are obtained by going from house to house in the village, each house being bound by law to provide food for the paupers so many days each year. I asked why the poor-house was not repaired, and was told that the peasants had purposely built it poorly, fearing that if it were comfortable it might encourage pauperism in the village. The poor are supplied with clothes either from the church or village treasury according to circumstances. A residence of two years in a village compels its inhabitants at the expiration of that time to support the applicant, nor can he be forced to do any work in return for his living. The one pauper in E—— was so distressing to the eye that I never passed him if I could avoid it. Blind and lame, hatless, coatless, shoeless, and covered with the mud in which he had slept, he seemed, as he crept from fence-post to fence-post, muttering curses on those who passed without giving him alms, to be forsaken alike by God and man. I can imagine him being, in the words of a dying tramp, "glad to have a hell to go to," but I can not believe that any moderately respectable imp would touch him without the aid of a pair of tongs. A gift of one cent would cause him to bless you until he had reached the nearest dram-shop; more than this I never dared to give, for fear of causing an inroad of beggars upon the village.

An imperial forester, with one or more deputies in each village of his district, has complete control of all the woodland in his circle. By him it is decided how much wood shall be cut each year for the use of the commune or corporation, and without his consent not a stick can be cut in any forest of his district. The commune of E—— owns fifteen hundred and thirty-eight acres of land, which has, since the settlement of the village many generations ago, been planted in forest-trees. None of this forest-land has ever been stripped of its trees and devoted to agriculture, with the exception of a small part, which, on account of its position near a much-traveled road, served during the Thirty Years' war as a refuge and place of ambush for brigands and highway robbers. This was, toward the end of the great war, cleared and the land divided among the corporators. The forest-land belonging to E—— is divided into forty parts, one of which may be cleared each year. On account of the large amount of extra labor caused by the keeping up of nurseries, but few villages plant the land cleared by them each year, most of them allowing the natural growth to spring up on the cut portions. Although the natural growth of wood on which E—— depends for its supply does away with the need for a large nursery, the corporators are yet compelled to keep up a small one, in order to plant high, wind-swept ridges where no seed has lodged. This nursery, or *Baumschule* as it is called, is planted and kept up by the labor of all the corporators. As a general thing, only two days out of the year are spent by each citizen at commune work. In the fall a meeting of the corporators is called, and it is then decided when and how much wood shall be cut. The imperial forester is at once notified, and, in company with the village forester, goes through the part which is to be cut that year and marks all trees under an inch in diameter except those which, from their fine form or good situation, seem likely to make first-rate timber. The whole of the woodland to be cut is then divided into sixty-six parts, and each corporator receives a part, allotted by chance, on which he at once goes to work and clears off the brush and marked trees. When this has been accomplished throughout the whole tract, the imperial forester is again called, and goes through the forest, marking all trees not large enough for building timber, and which are so warped, decayed, or top-killed as to be unlikely to grow into good timber. These trees are then divided as before, and each citizen cuts and carries away his share. Then, for the third and last time, the forester goes through the tract, and marks all the large trees which seem to be hollow-hearted or to have stopped growing. These are then divided and cut like the rest, with the exceptions that the oaks are first stripped of their bark to be sold to tanners for the benefit of the commune, and that the teacher and minister get none of this large wood because, the peasants say that, when a parsonage or a schoolhouse must be built, it is done, not by the minister or teacher, but by the people. The oak-bark is often worth more than all the rest of the wood of a forest. In starting pine-forests the cones are planted thickly in furrows, and, after the first weeding-out, are left untouched for ten years, at which time alternate trees are cut. This process is repeated every five years, till at the end of thirty years all the trees are cut; the successive cuttings being divided among the corporators.

When any one wishes to build a house in E——, he sends word to the village court, describing the kind of house and where it is to be constructed. Notices are then posted in the village, and, if no one sends written objections to the court before the expiration of fifteen days, the building is allowed, and can not be interfered with. It will be seen that the population of E—— consists of two classes: the few more fortunate, who possess village rights, and draw from these an income which considerably increases their comfort; and the less fortunate, but more numerous, who possess no share in the communal property. But no social distinction, so far as I could see, obtains between these two classes.

MAPS AND MAP-MAKING BEFORE MERCATOR.*

By CHARLES P. DALY, LL. D.

[*ABRIDGMENT OF AN ADDRESS BEFORE THE GEOGRAPHICAL SOCIETY.*]

THE materials for the history of cartography, or the art of map-making, are scanty. I propose to give a brief account of what we knew about it before the time of Gerard Krehmer, better known by his Latinized name of Mercator, who produced a large map of the world more than three centuries ago.

It is generally thought that the art of pictorial representation is older than the art of writing, and, if this be so, it is probable that the art of representation by maps is very ancient. Such delineations are in use among very primitive peoples. The Esquimaux understood the charts of Parry and Ross, and the North American Indians make rude maps, which they find serviceable to them.

One of the earliest things known in the nature of a map is the ground-plan of a town, now in the Koyunjik Gallery of the British Museum, which has been identified by Mr. Loftus as representing with minute accuracy the ground-plan of Susa, the Shushan of the Bible, a city of remote antiquity, situated on one of the streams that flow

* The Early History of Cartography; or, What we know of Maps and Map-making before the Time of Mercator. Address before the American Geographical Society in 1879, by Chief-Justice Charles P. Daly, President of the Society.

into the lower Euphrates, a little to the north of the head of the Persian Gulf, the country whence the people or race came that built Babylon, and founded the Chaldean civilization. The age of this topographical work is unknown, but it is assumed to be as old, at least, as the seventh century before Christ. It represents, in a rude form of design, the plan of the town, its walls, the citadel, the king's palace, and a central square surrounded on three sides by what is either a wall or a colonnade of buildings of uniform character. On the remaining square is a large gateway, and the suburbs surrounding the town are represented as planted with date-trees and interspersed with buildings to the banks of the river.

The Egyptians had maps, although but little is known of them. There is a papyrus preserved in the museum at Boolak containing a map of Lake Mœris, on the Nile. It shows the plan of the basin with its canal, and the position of towns and of certain sanctuaries upon the borders of the basin, with explanatory texts giving information respecting these places. There is also an old Egyptian map preserved at

FIG. 1.—HOMER'S WORLD.

Turin of what is now Wady Alaiki, where the Nubian gold-mines were situated, in the land anciently called Aki-ta. It is a mountainous country, of dreary, sterile, waterless valleys, where men and beasts died upon the roads to these mines. The map shows the mountain-tracts, the rocks, and the places where gold was found, the ore-bearing mountains being marked in red color. It also shows the wells, a temple erected to Ammon on the mountain, and the appurtenances and buildings in the gold-districts. The roads, which had been abandoned, leading to the sea, are also given. "Nothing," says Brugsch Bey, "is forgotten calculated to give the spectator an idea of the state of the region, even to the stones and the scattered trees along the roads." This description is sufficient to show that the Egyptians knew the value of maps, and that they made and used them. These gold-mines were worked in the reign of Rameses II., and if this map was made at that period, as from the description given of it would seem to be the fact, then it is the oldest map known.

It was very different, however, with their neighbors, the Phœnicians. They were the great maritime nation of antiquity, making constant voyages along the coasts of the Mediterranean on either side, and along the western coast of Europe, as far as Great Britain, and possibly farther. The outlines of a coast once seen would, it is true, be sufficiently preserved in the memory for the practical purposes of navigation; but a people who had extended their voyages so far, who had established so many colonies, and to whom is attributed the invention of the alphabet, would naturally be led to the construction of charts,

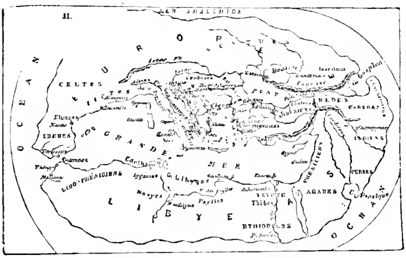

FIG. 2.—MAP OF HECATÆUS .B. C. 500.

from their utility, as well as maps to give some general idea of the world, of which they knew more than any other people. A jealous commercial policy kept them from imparting their knowledge to others, so that we do not know whether they had maps or charts; which is not remarkable, as we know, in fact, so little respecting them.

It is from the Greeks that we get our earliest knowledge of geographical maps. The first information we have upon the subject is from passages in Herodotus and Strabo. Strabo says that Anaximander, who was born B. C. 612, was the first who represented the world upon a map. Diogenes Laertes ascribed to him the invention of geographical maps, and also of the gnomon. But this he probably introduced into Greece, as it was in earlier use among the Chaldeans. Herodotus says that Aristagoras, when he went (504 B. C.) to Cleomenes, the King of Sparta, to induce him to invade Persia, produced before the Spartan king "a bronze tablet, upon which the whole circuit of the earth was engraved, with all its seas and rivers."

Hecatæus, who lived in the same century with Anaximander, is believed to have corrected and improved the map drawn by Anaximander. Hecatæus was, for his time, an extensive traveler. He was well acquainted with Egypt and Western Asia, and embodied the information he had collected in his travels in two geographical works, that have not come down to us, which were of great authority for several centuries after his time.

What these early maps were we do not know, but can form a reasonable conjecture. The earth at that time was supposed to be a flat circular plain, or disk, the broadest part being from east to west, which was entirely surrounded by an ocean, or great river, that washed it upon all sides. In about the center of this plain Greece was supposed to be situated. The great central sea of the inhabited region was the Mediterranean. The farthest point known at the west was the Straits of Gibraltar, then called the Pillars of Hercules. The southern part comprised the north of Africa as far as the deserts; while the region north embraced the countries bordering upon the Mediterranean, and an unknown hyperborean land farther to the north, with the Euxine and Caspian Seas at the northeast. The farthest eastern point known was about the western limit of India. This was what would then be contained in a map as a representation of the earth. The sun was supposed to pass under and around this flat plain, which was then the mode of accounting for the changes of day and night. The space beneath was supposed to be a great vault, called Tartarus, the abode of the spirits of the wicked among men, as the region corresponding to it, above the plain, was the heaven, or abode of the gods. The unknown region beyond the Pillars of Hercules was filled up with creations of the fertile imagination of the Greeks. To the northwest and

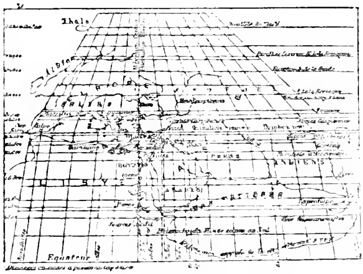

FIG. 3.—HIPPARCHUS, 100 B. C.

north were the Cimmerians, a people living in perpetual darkness; and the hyperboreans, a race supposed to be exempt from toil, disease, or wars, who enjoyed life for a thousand years in a state of undisturbed serenity. To the west of Sicily were the enchanted islands of Circe and Calypso, and the floating island of Eolus. A little to the north of the Pillars of Hercules was the entrance to the infernal regions; and far out in the Western Ocean, beyond the limits of the known earth, was the happy region called Elysium, a land of perpetual summer, where a gentle zephyr constantly blew, where tempests were unknown, and where the spirits of those whose lives had been approved by the gods dwelt in perpetual felicity. Here, also, were the gardens of the Hesperides, with their golden apples guarded by the singing nymphs, who dwelt on the river Oceanus, which was in the extreme west, and the position of which was constantly shifted as geographical knowledge increased.

When the idea became firmly fixed in the mind of the learned that the earth was a sphere, it naturally followed among an artistic people like the Greeks that some attempt would be made to give a physical

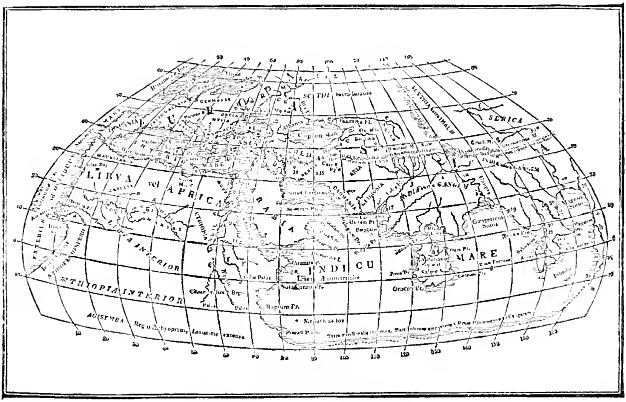

Fig. 4.—Ptolemy's Map, A. D. 150.

representation of it, and accordingly we are told that Crates (B. C. 326) constructed a globe of the inhabited part of the earth, from the Arctic to the Tropic, in the form of a half-circle. The zone about the tropics he represented as an uninhabitable portion, entirely covered by water (a belief which existed for a long time afterward), and the southern half beyond as that of an unknown but inhabited region. Dicearchus the Messinian (B. C. 296), a very accomplished man, and the writer of several geographical works, which are lost, constructed a map of the world in an oval form, which appears to have been highly estimated, and to have been the model upon which subsequent maps were made. It is inferable from passages in the classic writers that the maps in use represented the unknown parts of the world, in conformity to the ideas deeply implanted in the popular mind by the poems of Homer and from other sources. With Eratosthenes, who died about the beginning of the second century before Christ, the science of geography may be said to have begun. He was the first to apply a purely scientific method to ascertain the magnitude of the earth; for, when a knowledge of the exact circumference of the globe was once obtained, the different countries and places could be arranged in these ancient maps, in their relative position to each other, far more accurately. The distances between places in what was then known as the inhabited part of the earth were previously ascertained by the number of days it took to go from one place to another, derived from the information of travelers and mariners.

To rectify the errors which became more apparent and confusing as the inhabited part of the world became better known, Eratosthenes devised, what has ever since been employed as the most accurate means of determining the circumference of the earth, the measurement of an arc of the meridian. He found a confirmation of the globular form of the earth in the fact that at Syene, in Upper Egypt, upon the tropic, the sun at noon on the day of the summer solstice was vertical—that is, that it cast no shadow, a well at the bottom being enlightened by its rays; while at Alexandria, upon the same day and time, it was distant from the zenith one fiftieth of the circumference of the circle. Eratosthenes obtained by this means the length of what is called an arc of the meridian, or a portion of the curved surface of the earth; and from this he was able, by a familiar rule, to determine the circumference of the whole circle.

The happy idea occurred to Hipparchus of applying to the earth the same method he had used in fixing the position of the stars in the celestial sphere. Regarding the earth as a great circle, which, like any other circle, is divisible into three hundred and sixty degrees, he so divided it, by lines of circles drawn perpendicularly from the poles to the equator, and by parallel lines at equal distances from the equator to the poles, which was the beginning of the division of the globe by lines of longitude and latitude into degrees.

The Romans, in their representation of the earth, at first followed Eratosthenes and Hipparchus. The Emperor Augustus ordered the geographers and designers to prepare for the use of the people a map of the habitable world which should represent fully the extent of the Roman Empire; and, from some fragments that were preserved, it is known that this map was a cylindrical projection of a great circle. The Romans, however, had a map for practical use, which they styled a *descriptive itinerary*, or, as they sometimes called it, "*painted roads.*" This map was in the form of a band, about a foot wide and about twenty feet long, upon which the habitable earth was continuously represented along parallel spaces. It represented pictorially the great routes or roads of the empire, the position of places with the distances between them, the ranges of mountains, and the direction of rivers. This kind of map was mainly used for military purposes, and was regarded as a map of the world, for the vast extent of the Roman Empire comprised nearly all that was then known of the habitable world.

Fig. 5.—Claudius Ptolemy. (From an Old Map.)

Great progress was effected in map-making by Marinus of Tyre, who lived during the second century of our era. He studied with great care the works of his predecessors, collected all the information that was procurable from travelers and mariners, and produced a geographical work far beyond anything that had preceded it, illustrated by maps which were covered with a network of parallel and meridian lines, cutting each other at right angles, under which the different places were indicated according to their direction and distance from each other. His object was to put an end to the uncertainty about the position of countries and cities, by assigning to every locality or place its approximate latitude and longitude. He divided the globe into sections, each having an astronomical extent of fifteen degrees, and the places falling within these limits he put together in what he supposed to be their relative position to each other. He drew a line due east from the Fortunate Islands, and arranged countries and places in what he regarded as their proper position north and south of this line, so as to bring them alike under the proper zone or climate, as well as under the astronomical section he had devised.

Marinus was probably the first who undertook to combine systematically the results of astronomical observations with those of travelers and mariners in determining geographical positions. There being no delicate instruments to indicate direction, altitude, or time, the latitudes and longitudes ascertained were at first, of course, erroneous. Marinus corrected earlier errors, and accumulated much new material for the preparation of a geographical work which premature death prevented him from perfecting.

The geography of his immediate successor, Ptolemy, which has fortunately come down to us, was written at least within half a century afterward, and, as Ptolemy himself says, was based upon the work of Marinus.

Ptolemy's labor was what in this day we should call editing a new and revised edition of an existing work. Ptolemy was a much better mathematician and astronomer, but evidently very inferior as a geographer to his predecessor. He undertook to correct Marinus's chief error by reducing his projection of the earth, from east to west, from 225° to 180°. In making this geometrical correction, however, he fell into a multitude of errors which, had he been a better geographer, he would readily have detected.

A period of twelve hundred years elapses from the time of Ptolemy to the inauguration, by Prince Henry the Navigator, of Portugal, of the spirit of maritime enterprise which led to the circumnavigation of Africa, and the discovery of the Continent of America. This long interval is marked by the decline in Europe of everything in the form of geographical knowledge, until a state of ignorance was reached in which little interest was felt in any branch of human learning. For the purposes of our inquiry it may be divided into three periods. The first was one of long-continued and nearly incessant wars, during which the destruction of everything was so great that, when it closed, there was little remaining but fragments of the ancient civilization. This was followed by a period of repose, ignorance, and torpor, to which succeeded another period, ending about the beginning of the fifteenth century, during which a limited few were slowly recovering a portion of the geographical knowledge that had been lost, and dimly groping their way to a true conception of the earth's form and laws.

FIG. 6.—MAP OF THE WORLD, TENTH CENTURY.

But, though geographical knowledge declined during this interval, and from the sixth to the middle of the eleventh century the condition in Europe, except in Spain and in Ireland, was one of almost universal ignorance, there was throughout the whole of the period some attention, at least, given to geography—to the study of maps and to map-making. It was, it is true, very little, and the greater part of it tended more to obscure than to enlighten; but at no time was the interest in the subject wholly extinct. For several centuries after the time of Ptolemy, or up to the separation of the eastern from the western half of the Roman Empire, there was an almost uninterrupted study of geography in the schools of Alexandria, in which the fathers of the Church, the philosophers, the soldiers, and the emperors appear to have taken a warm interest. The maps then in use were itineraries or road-maps, which were very numerous, as they were of service to the soldiers during the wars that were then and which continued long afterward to be waged. In addition to these route-maps, general maps were also constructed, to show at a glance the form and proportions of the habitable globe; and in the fifth century Theodosius II. caused a survey to be made of the provinces of the empire, which occupied fifteen years, from which a large map of the empire was compiled. There was also a geographical school at Ravenna, in

Italy, which, after Honorius (A. D. 404) made Ravenna the capital of the Western Empire, became very active, but the cartographical labors of this school appear to have been limited to the production of descriptive itineraries or painted route-maps. The authority of Ptolemy, during this period, declined. The Alexandrine geographers, no doubt, were better acquainted than he was with Asia, and knew the gross errors he had made in the configuration of countries and the position of places. But there was another and more potent cause that led to the discrediting of Ptolemy, as well as of all the ancient geographers. This was the disposition of the clergy, who for some centuries after-

FIG. 7.—ARAB MAP OF THE WORLD, A. D. 1009.

ward were the only learned class, to test all geographical knowledge by the standard of the Bible ; and, as the Bible afforded no authority for the opinion of the ancient geographers that the earth is a globe, their ideas and their works were generally rejected as contrary to Holy Writ. In the middle of the sixth century Cosmos, who had been a merchant, an extensive traveler, and who afterward became a monk, was the writer of several geographical works, one of which has survived, in which he maintained that the idea of the earth being a globe was contrary alike to the Scriptures and to common sense ; sustaining his views by ingenious arguments, which, in that age, were very convincing. Cosmos was not an ignorant man ; on the contrary, his account of the countries with which he was acquainted was accurate and valuable, and it was his topographical knowledge which made him so formidable an antagonist in disputing the rotundity of the earth. "There are," he says, "false Christians, contemners of the authority of Scripture, who dare to maintain that the earth is a sphere. I combat this error, derived from the Greeks, by citations from Holy Writ." He then ridicules the idea that the earth revolves in space without axis, or anything to support it, and characterizes the belief of antipodes, or people living on the other side of a round globe, as old women's tales. Having thus disposed of the anterior belief, he proceeds to give his own idea of the earth, which he says no true Christian can doubt. It was, that the earth was an oblong plain, inclosed at its four extremities by huge walls of immense thickness, on which the firmament or vault of the heavens rested; and that near the north pole there was a high mountain, around which the sun, the moon, and the stars turned, the intervention of which mountain, at certain periods, caused eclipses.*

We have now approached a period when Europe sank into the deepest ignorance, communication between places was broken up through the long continuance of wars; roads were destroyed, there was little or no commerce, for traveling was difficult and dangerous, and people in close proximity knew comparatively nothing of each other. Fortunately, however, this was not the state of things throughout the world. During the period that marks the rise, the maturity, and decline of the empire of the Arabs, or from the ninth to the thirteenth century, geography was assiduously cultivated by them as a science, especially in Bagdad, the capital of the Caliphs, and for a part of that period in Spain. It is to the Arabians that we owe the preservation of the work of Ptolemy, which they translated into Arabic and annotated. They determined the obliquity of the ecliptic, measured two arcs of the meridian, ascertained more accurately the longitude of places in Asia and about the Mediterranean, and enlarged descriptive geography by an account of the countries in Asia over which they had extended their conquests. As early as the ninth century they trafficked in the ports of the Indian Ocean, and had intercourse also at that time with China, through which probably the mariner's compass was brought to the Mediterranean. I may also mention in this connection that the Chinese, according to the statements of their own writers, had maps from a very remote period. These are described as representing the mountains, seas, rivers, lakes, plains, and basins, and were compiled by order of the emperors.

The Arabian geographers prepared an elaborate work (A. D. 830) founded upon Ptolemy. It is lost, but, from the references to it by Arab writers, we know that it gave a description of the habitable earth, and indicated the prominent places in different countries by their latitude and longitude, correcting, in the countries in which the Arabs were well acquainted, the gross errors in longitude of Ptolemy. It is from these tables of latitudes and longitudes that we know the wide extent of the geographical knowledge of the Arabs. Their corrections from west to east extended from Cadiz to the Indus, and they restored to their true position the places in the countries watered by the Euphrates and the Tigris. It is inferable, from statements of Arab writers, that they had maps constructed upon a mathematical basis.

* See "Popular Science Monthly," vol. x., March, 1877, article "How the Earth was regarded in Old Times."

As these maps have not come down to us, it is supposed that they were rare, and were not intended for practical use, but constructed to aid the inquiries of the learned; for the Arabians pursued the study of geography mainly in its connection with astronomy, and were not, as we would understand the term, topographers, or only to a very lim-

FIG. 8.—EDRISI'S MAP, A. D. 1154.

ited extent. It is rather for the preservation of what was previously known that we are indebted to the Arabs; for, though they studied geography with great assiduity, they can not be said to have greatly advanced it as a science.

Leaving the Arabs and their labors for the present, we will now return to the growth of cartography in Europe. We have maps designed to represent the earth as known, or particular parts of it, from the ninth to the fifteenth century; and which, from the rude efforts in the ninth century, exhibit the widest diversity in plan and execution. Some consist of straight parallel lines drawn across a circle, with the names of countries or places arranged along the lines. In others, the position of the Mediterranean is indicated simply by the name of the sea, and the names of countries and places are grouped about it in what was supposed to be their true position. In none of these early maps is there any attempt to give in curved lines the form of continents, or to indicate the boundaries of countries.

About the middle of the twelfth century, Roger, King of Sicily, determined to have a map of the world constructed from the best in-

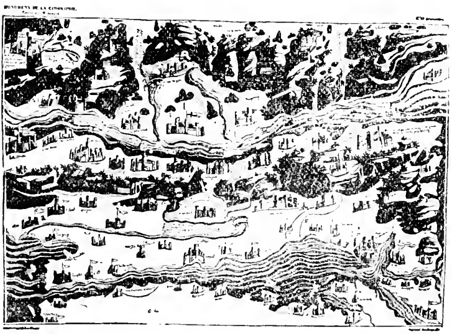

Fig. 9.—Italian Itinerary, Thirteenth Century.

formation that could then be obtained. For this purpose he sent intelligent men to various parts of the known world, to take the latitude and longitude of places, to collect itineraries, and gather every kind of information that was desirable. Fifteen years were spent in this preparatory work, and what had thus been obtained was intrusted to Edrisi, an Arabian geographer and traveler, who had been invited to the King's court, and from these materials Edrisi compiled a general map, which was engraved upon a round table, or globe of silver. In a manuscript in the National Library of Paris there are sixty-nine maps, supposed to have been copied from this silver globe, and there is a general copy of the map attached to a manuscript in the Bodleian Library at Oxford. This work of Edrisi was superior to anything that had preceded it in the middle ages. It appears to have given a new impulse to geographical inquiries, as it was compiled chiefly from the new materials that had been obtained ; for Edrisi, upon examining the works of his Arabic predecessors and the work of Ptolemy, found that they had involved the general subject of geography in such doubt, uncertainty, and confusion, that in constructing his map he rejected them altogether as sources of authority. Edrisi also composed a geographical work which has survived. Wherever in it he had to refer to the fabulous and impossible things asserted by his predecessors, he generally accompanied the statement with the formula, "God only knows how this is."

To understand more clearly the rapid progress which was made in cartography in Europe in contrast with the little that was done for its improvement by the Arabs, it will be necessary to draw attention to the difference between the nature of the empire which they established and that era of maritime enterprise and commercial activity which sprang up, and after the twelfth century developed so rapidly in the cities of the Mediterranean. The Arabs had a vast empire, the great bulk of which had no connection with the sea. A highly imaginative people, they were more attracted by speculative inquiries respecting the earth as a whole, and therefore studied it more in its connection with astronomy than by those careful, patient, and practical topographical labors which constitute such an important part of geography. What could be done by astronomical observation to show the relative position of places they did; but they knew nothing of the Atlantic.

The people of the maritime cities of the Mediterranean had a field of activity very limited when compared with the great empire of the Arabs. It was the Mediterranean. Their pursuits were maritime. They were the carriers by water of products between Asia and Europe, and therefore became, what the Arabs never were, a nautical people. To them navigation and everything that tended to its improvement were of the highest interest, and they consequently gave great attention to details. They observed closely the outlines of coasts, carefully delineated them, and, as they had an eye for form and proportion, their maps, in design and execution, greatly excelled those of the Arabs.

These cosmographers knew very well the position of places to the pole, or geographical latitude, but in making their maps they drew no parallels of latitude, and paid less attention to longitude: for the mariners for whose use these maps were intended knew nothing about figures representing degrees of latitude and longitude, and they are consequently not found upon these maps. The distances on the land or over the sea were laid down from certain fixed points in the direction of the compass, and hence these maps are covered with a network of lines running in all directions from central points, called wind-roses (*rose de vent*), which, to persons familiar only with maps of the present day, are unintelligible.

In the fifteenth century, great acquisitions were made to the knowledge of the world, especially in Asia and Africa, by the journeys of Marco Polo and Cadamosto; and the result of this accumulation of new information was the construction, in 1457, of a large map of the world, by Fra Mauro. It was painted on the wall of a convent in Venice, and was, for its time, an admirable production.

Fra Carmelite was a friar who had established a geographical school in Venice, and whose acquisitions as a geographer were, for the time, so extensive that he received from his contemporaries the title of "*the incomparable*." He knew that the earth is a sphere—being well acquainted with Ptolemy, but did not follow Ptolemy's scientific method of so projecting the world as to give the longitude and latitude of places. It should be stated, as explanatory of the defective construction of general maps of the world at this time, and before it, that the belief of the ancients in the globular form of the earth was far from being generally accepted. Even among cosmographers there was great uncertainty as to its real form. Columbus thought it had the shape of a pear, and in fact its spherical form was not fully admitted until Magellan's vessel, in 1521, sailed around it. In Italy, however, the belief of the ancients, both as to the form and as to the motions of the earth, was revived as early as the middle of the fifteenth century.

About forty years before the map of Fra Mauro was executed, Prince Henry of Portugal, surnamed the Navigator, began to send out those expeditions along the western coast of Africa which were the beginning of that brilliant age of maritime exploration that led to the circumnavigation of the Cape of Good Hope, the discovery of the Continent of America, and the voyage of Magellan's vessel around the world. During this period of active discovery, the limits of Africa were greatly extended to the south, a vast continent was revealed by the discovery of America, and, the knowledge of the earth being thus largely augmented, a general map of the world had to be differently arranged and represented by new methods.

The first map upon which the discoveries of Columbus appear is that of John Ruysch, in the edition of Ptolemy printed in Rome in

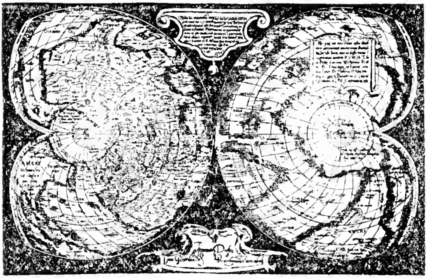

Fig. 10.—Mercator's First Map. a. d. 1538.

1508. Ruysch adopted the method of Ptolemy of projecting the earth in the form of a cone, with the Arctic at the summit, but so expanding the cone as to bring in the Western Hemisphere and show the islands and a part of the mainland discovered by Columbus and others. In 1511 Bernard Sylvanus produced in his edition of Ptolemy a general map of the world, upon what has since been called the cordiform or heart-shaped projection, which, while giving the whole of the geographical features of the earth, was, from the curve and sweep of the parallels of both latitude and longitude, better adapted than anything that had preceded it to convey upon a plane surface a general idea of the earth's globular form. In this map the newly discovered continent of America, under the name of "The Land of the Holy Cross," was laid down more fully and accurately than in the preceding map of Ruysch. In the following year, 1512, a Polish geographer, John de Stobnicza, in an introduction to Ptolemy, published a map which I regard as of great interest, as it was, as far as I have been able to ascertain, the first attempt to project the spherical surface of the earth upon a plane. If I am right in this supposition, it was the parent of the mode now in use in all atlases of representing in a map of the world both sides of the globe upon a flat surface by two planispheres, or circular maps joined together, one of which includes Europe, Asia, and Africa, and the other America, North and South. This map was constructed to represent that half of the globe which was unknown to Ptolemy, or substantially what is now known in maps of the world as the Western Hemisphere.

The main object of this interesting map was to show where this newly discovered land was situated, and place it in its true position with respect to the whole globe. The map is but a partial or subspherical projection, being cut off at the seventieth degree north latitude, and at the fortieth degree south latitude. The Continent of America, North and South, is represented as running northwesterly to the center of the map, and as extending from 70° north latitude to 40° south latitude, the shape of the continent as then understood being evidently derived from a chart, not then published, which, from an inscription upon it, is supposed either to have been drawn by Columbus, or under his direction. The breadth and general shape of South America, though rudely given, are remarkably correct. The isthmus separating South from North America is laid down, but exaggerated in length; and a small portion of North America is given, its extension to the west being left undefined. The position which the whole continent occupies as a part of the globe is, as would be expected, not correctly laid down, but, as a conjectural representation of its exact position, the map was for that time (A. D. 1512) a very remarkable production.

I have dwelt upon this map, because it has not received from geographers the attention it deserves; and for the further reason that it furnishes a striking illustration of the slow progress of geographical knowledge; for the projection of maps of the world, upon the same scientific method, did not come into general use until about the beginning of the last century, or nearly two hundred years afterward.

In 1520 Peter Benewitz constructed a map of the world in the form of a heart, after the method of Sylvanus, which has acquired a celebrity as the first map upon which the name of *America* appears.

In 1531 Oronce Fine undertook to improve this by a projection in the form of a double heart, so as to give, by that method, upon a plane or flat surface, both sides of the globe; and in 1538 Mercator, then a young man of twenty-eight, published a map of this double-heart projection, making many corrections, especially in respect to the Continent of America, of which only one copy is known to exist, attached to an

FIG. 11.

edition of Ptolemy of 1578, that belonged to Mercator, and which has been liberally deposited by a member of our council, J. Carson Brevoort, in the library of our society.

All these maps, in their delineation of the outline of countries, were very defective, and especially in respect to the Continent of America. The accessions to geographical knowledge had become so vast and the details were so enormous that the work of giving the whole of the surface of the earth, as far as known, with all the details of continents, oceans, gulfs, bays, straits, rivers, mountain-ranges, and islands, with any marked approximation to correctness, was not accomplished until Mercator produced his great map of the world in 1569 ; which, when the fullness of its details is considered in connection with the new and scientific method upon which he projected it, entitles him to the appellation of the father of modern cartography. In this map he introduced what has ever since been known as Mercator's projection, which not only gave the world in one view, but by an ingenious and simple contrivance showed the most effectual way for a vessel to sail in a straight line over a curved surface, and thereby solved what was before one of the most difficult problems in navigation. That projection constitutes, down to the present day, the basis of every chart that is constructed to guide the mariner in his way over the ocean, and the map of the world on his projection is to be found in nearly every English or American atlas that has been published for a century and more, and yet the inquirer would search in vain in any work in the English language for the particulars of Mercator's life, or for any satisfactory account of what he did. How little is known respecting him, even by nautical men, will be sufficiently indicated when I state that, upon speaking about him not very long ago to a distinguished admiral, he looked at me and exclaimed : " What ! was there such a man as Mercator ? I always supposed Mercator's projection meant the merchant's projection."

ANCIENT METHODS OF FILTRATION.*

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THE separation of a liquid from solids suspended in it, by straining through some material pervious to the one and impenetrable to the other, was a familiar process in the remotest antiquity. Observation of various processes in nature, such as the purification of water by trickling through sandy soil, or perhaps the accidental passage of rain-water through an outstretched cloth, a garment, or a tent-cover, would obviously suggest the simple expedient. History fails to record the period of the invention or the name of the individual who first put it in practice. Etymological considerations show that filters were early made of fulled wool or felt ; the Latin *filtrum*, " a filter," being closely connected with *feltrum*, " felt," or compressed wool, and both are related to the Greek πῖλος, signifying hair.

Several writers on the history of science make casual reference to

* Read before the New York Academy of Sciences, October 13, 1879.

the operations performed by the early chemists: some state in a general way their acquaintance with the processes of distillation, sublimation, filtration, etc.; others are more explicit. Hermann Kopp, in his exhaustive "Geschichte der Chemie,"* states that "filtration as a chemical process was first accurately described by Geber, who calls it by a special name, *destillatio per filtrum*, 'trickling through a filter,' in contrast to the collection of a liquid by ordinary distillation." Ferdinand Hoefer, in his "Histoire de Chimie" † writing of Geber, mentions that he recognizes two kinds of distillation—with and without fire—the former being "per alembicum," and the latter consisting of "une simple filtration."

Now, we propose to show that the ancients carried on the operation of filtration in two ways, essentially distinct in principle and in the manner of execution, and that these methods were characterized by two different expressions which have been confounded by the authors named. Moreover, we shall establish this by quotations from writings covering a period of more than two thousand years.

In the first place, an examination of the very passage in Geber's Works, referred to by Kopp and by Hoefer, shows that the method therein described differs radically from filtration as ordinarily conducted at the present time. We quote the passage as found in the works of Geber, "the most famous Arabian Prince and Philosopher," "faithfully englished by R[ichard] R[ussell]," and printed at London in 1678. In the thirteenth chapter of the fourth part of the first book of the "Summe of Perfection," Geber treats of the three kinds of distillation: by an "Alembeck," by a "Decensory," and "by Filter." After describing in quaint language the well-known method of using the alembic and the decensory (which differs chiefly in the application of heat on the top of the apparatus), Geber writes thus of filtration: "The *Disposition* of that which is made by *Filter* is, that the *Liquor* to be *Distilled* be put into a *Stone Concha*, and the wider part of the *Filter* put into the said *Liquor*, even to the *Bottom* of the *Concha*, but the narrower part of it hang out over the *Orifice* of the said *Vessel*. And under that end of the *Filter* must be set another *Vessel* for receiving the *Distillation*. Therefore when the *Filter* begins to *Distill*, the *Water* with which it was moistened will first *Distill* off; which ceasing, the *Liquor* to be *Distilled* succeeds. Which *Liquor*, if it be not as yet serene, it must so often be put into the *Concha* again and redistilled, as until it be *Distilled* most serene."

This dates from the eighth century, and evidently describes a sort of capillary siphoning. The expressions "placing the wider part of the filter" into the liquid and allowing the "narrower part of it to hang out over" the vessel admit of no other interpretation. For convenience of distinguishing this method of filtration from that in which porous sacs are employed, we propose to name the former

* Vol. ii., p. 26.

† Vol. i., p. 335.

anethisis, a word made from ἀνά, "upward," and ἤθισις, "a straining off." A study of the chemical works of the middle ages further shows that the expression "*destillatio per filtrum*" is invariably used to describe *anethisis*, while "*filtratio*" is applied to ordinary filtration. We shall give quotations proving this, but first make brief reference to early records.

The ancient Egyptians portray in the rock-cut memorials the operation of filtration in connection with the manufacture of wine. Their simple wine-press consisted of a bag in which the grapes were placed, and squeezed by means of two poles turned in contrary directions. Small colanders of bronze have been found at Thebes. Views of the interior of an Egyptian kitchen, cut in the tomb of Rameses III. at Thebes, represent siphons in use for drawing off liquids of various kinds. (Wilkinson.) The ancient Romans employed strainers and colanders (*colum*) made of a great variety of materials. Wine-strainers were made of silver and bronze; the poorer classes used linen, and, where nicety was not required, they used those made of broom or of rushes. Strictly speaking, however, percolation through colanders is not filtration, for capillary action plays no part.

It is interesting to note that the earliest mention of filtration which a brief search has disclosed refers to the method we have ventured to call *anethisis*. This occurs in Plato's "Symposium," written about four hundred years before the Christian era; the passage is as follows: "Socrates then sitting down, observed, 'It would be well, Agatho, if wisdom were a thing of such a kind as to flow from the party filled with it to the one who is less so, when they touch each other, like water in vessels running by means of a thread of wool from the fuller vessel into the emptier.'" *

Aristotle, the pupil of Plato, in his essay "De Generatione Animalia," refers to the other process in the following words: "Flesh is produced, therefore, through the veins and pores, the nutriment being deduced in the same manner as water through earthen vessels not sufficiently baked."

This passage, together with others occurring in Plato, shows that both systems of filtration were employed at that early period.

Geber, whose clear description of anethisis we have quoted, was followed by the celebrated Arabian physician, Rhazes; he uses the same expression, "destillatio per filtrum," in the following passage: "Dissolve as much [common salt] as you wish in five times as much warm soft water, and distill per filtrum and congeal [i. e., crystallize]." † Rhazes died about 930 A. D.

Among the early writers on alchemy, no one is oftener quoted than Raymund Lulli, surnamed the Enlightened Doctor (born 1235, died

* Plato's works, Burges's translation, vol. iii., p. 480 (Bohn).

† "Collect. ex Rhasi in Margarita Pretiosa Novella" of Petrus Bonus (1330), Venetia, 1546.

1315 A. D.). In his works we find the following characteristic passage: "Take, in the Name of God, great Bay Salt, as it is made out of the Sea; take a good quantity and stamp very small into a stone-morter: then take Cucurbites of Glass and pour your Salt therein: then take fair Well-water, and let your salt resolve into cleer water; being all dissolved then distil it by Filter; that is to say, hang a jag Felt or Woolen cloath in the Cucurbite; and let the other end hang in another Glass beside it, set as it were under it, that the water may drop into it that the Felt or Cloath may draw out and that shall be cleer as silver."

This unmistakable description of anethisis occurs in the first chapter of a booklet bearing the following title: "Philosophical and Chymical Experiments of the Famous Philosopher Raymund Lulli . . . . wherein is contained . . . . the admirable and perfect way of making the great Stone of the Philosophers as . . . . sometimes practised in England by Raymund Lulli in the time of King Edward the Third." London, 1657.

Thomas Aquinas, the eminent scholastic teacher of the thirteenth century, who is best known by his theological and metaphysical works, also paid some attention to scientific pursuits, possibly acquiring this taste from his learned master, Albertus Magnus. Aquinas, or the divine Thomas, as he was called by his admirers, defines distillation to be the "purification of waters falling drop by drop, and effected by placing a filter cut in the shape of an iron dart in the little dish containing the water to be distilled." *

Libavius, in his remarkable work, "Alchymia," sometimes called the first text-book of chemistry (published in 1595), devotes two entire chapters to the subjects of distillation and of filtration.† In the fourteenth chapter he describes, with much attention to detail, the manner of filtering by means of pieces of felt (*lacinia*) shaped like an ox-tongue, the broader portion of which is placed in the vessel containing the liquid to be filtered, and "the apex in the recipient, or, if the vessel has a narrower neck, in a suitable funnel." This demonstrates that the method was not resorted to on account of the want of proper funnels, and suggests that perhaps a special virtue was attributed to a liquid thus purified.

Libavius's work contains rude woodcuts illustrating different methods of procedure. For perfecting the purification a series of four vessels was used. These were placed on steps, one above another, and the liquid passed through a capillary siphon from the uppermost to the one immediately below, and thence by another siphon to the third vessel, and so on to the fourth. This series of vessels can be inclosed in a glass-covered box for filtering volatile liquids. Another woodcut represents the lower end of a capillary siphon hanging into a

* "Pretiosa Margarita Novella" of Petrus Bonus (1330), Venetia, 1546.

† "Comment. Alchymia," Part I., lib. iii., edition 1606.

funnel inserted in the neck of a flask. The method thus clearly portrayed is called *destillatio per lacinias,* and is evidently regarded as a process of distillation; ordinary filtration through porous stones and through bibulous paper is treated in another and following chapter.

Libavius makes reference to "Hippocrates's Sleeves,"* by which name were designated conical felt bags used in filtration.

Sir Robert Boyle, in his "Experiments touching the Spring of the Air," writes as follows: "Some learned mathematicians have of late ingeniously endeavored to reduce filters to siphons, but still the true cause of the ascension of water and other liquors, both in siphons and in filtration, [requires] a clearer discovery and explication."† And in another place he gives this "explication": "The parts of the filter that touch the water being swelled by the ingress of it to their pores are thereby made to lift up the water till it touch the superior parts of the filter that are almost contiguous to them; by which means, these being also wetted and swelled, raise the water to the other neighboring parts of the filter till it have reached the top of it, whence its own gravity will make it descend."‡

These passages can only apply to anethisis, which was apparently a common method of filtration in Boyle's day.

Again, to trace this process still later, Juncker, in his "Conspectus Chemiæ," published in 1730, describes seven kinds of filtration. These differ chiefly in respect to the materials used: two methods, however, are essentially distinct; the one is styled "*filtratio per chartam bibulam . . . in fundibulo vitreo*" (filtration through bibulous paper in a glass funnel), and the other is described in the words "*per segmentum panni lanei vel laciniam bombycinam vel funiculos gossypii*" (through shreds of woolen cloth, silken threads, or through little strings of cotton).

Our friend Professor S. A. Lattimore sends us another reference to this process from "The Laboratory or School of Arts, etc., compiled by G. Smith, sixth edition, London, 1799" (vol. i., p. 435); the passage is as follows:

"*To separate Water from Wine.*—Put into the cask a wick of cotton, which should soak in the wine by one end and come out of the cask at the bung-hole by the other; and every drop of water which may happen to be mixed with the wine will still out by that wick or filter."

Thus we see that, so recently as the close of the last century, anethisis was accounted a practical method of filtration.

* The origin of this curious term we have been unable to discover, nor is it of common occurrence in early writings on chemistry and pharmacy. The only explanation of the expression which we have as yet found occurs in the "*Lexicon novum Medicum Græco-Latinum*" of Stephen Blancardus, published in 1702. This author writes as follows: "*Manica Hippocratis* est sacculus laneus figura pyramidali, quo vina aromatica et medicamentosa, aliique liquores percolantur; ex 'υπο *sub* et κεραννμι *misceo.*"

† Boyle's Works, London, 1772, vol. i., p. 79.

‡ Idem., vol. iii., p. 233.

We have not found this method in Boerhaave (1727), nor in Lemery (1675), nor does Faraday, in his "Chemical Manipulations," make any allusion to it. As a process of purification of solutions, it seems to have been lost sight of in modern laboratory practice.

We have made trial of the method rendered noteworthy by more than two thousand years' practice, and find that, while the process is quite slow, it has certain advantages. Chief among these is the fact that, when the capillary siphon is adjusted, it requires no further attention ; there is no pouring into a constantly emptying funnel, and there is no possibility of overflow. When properly arranged, the last drop of liquid passes from the upper vessel to the lower, and, except in certain cases of extreme divisibility, the filtration is perfect. The process seems particularly adapted to the purification of weak solutions, as of mineral waters, where the insoluble portion is not to be conserved. There is obviously much choice in the material of which the capillary siphon is made. We have tried cotton, wool, lamp-wick, and asbestus, and we find stout, silky wads of the latter most serviceable ; it is also useful for filtering very acid and alkaline solutions.

The rapidity of filtration does not seem to be hastened by lengthening the longer arm of the siphon, and is chiefly dependent on the number of threads in the filter, and on their fineness. In one experiment, thirty-two strands of cotton yarn filtered twice as fast as sixteen strands, and only half as fast as sixty-four strands. Oil filters much slower than saline solutions, and the latter much slower than pure water.

We have used the expression "capillary siphoning" in describing anethisis, and perhaps it needs justification. The ascension of the liquid is due to capillarity, and the descent through the longer arm of the siphon is in obedience to gravity. Siphoning is dependent on atmospheric pressure, and can not be strictly applied to the present case ; yet we find by experiment that, if the lower arm of the woolen threads be raised to the level of the liquid to be filtered, the action ceases, and the form of a siphon is at all events essential to the process.

The quotations from ancient authors show that they must have been quite familiar with capillary attraction, yet the first observance of this phenomenon is attributed by some authorities to Franciscus Aggiunti, physician to the Grand Duke of Tuscany, about the beginning of the seventeenth century.* (Aggiunti died 1635.)

In conclusion, the object of this paper is not to propose a return to this ancient method of filtration, the modern rapid processes being more in accordance with present needs ; but we have thought it not altogether useless to call attention to a neglected process which can in certain cases be employed with advantage. Where the object of filtration is to collect the insoluble portion, it is obviously of no value ; whether the process could be advantageously used on a large scale remains to be tested.

* Gehler's "Physikalisches Wörterbuch," article "Capillarität."

JOHN STUART MILL.

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VI.

CLOSELY connected both in date of composition and in subject-matter is the "Utilitarianism." I find from a letter that it was written in 1854. It was thoroughly revised in 1860, and appeared as three papers in "Fraser's Magazine" in the beginning of 1861. I am not aware that any change was made in reprinting it as a volume, notwithstanding that it had a full share of hostile criticism as it came out in "Fraser."

This short work has many volumes to answer for. The amount of attention it has received is due, in my opinion, partly to its merits, and partly to its defects. As a powerful advocacy of utility, it threw the intuitionists on the defensive; while, by a number of unguarded utterances, it gave them important strategic positions which they could not fail to occupy.

It is this last point that I shall now chiefly dwell upon. What I allude to more particularly is the theory of pleasure and pain embodied in the second chapter, or rather the string of casual expressions having reference to pleasures and pains. I have already said that I consider Mill's Hedonism weak. I do not find fault with him for not having elaborated a Hedonistic theory; that is a matter still ahead of us. My objection lies to certain loose expressions that have received an amount of notice from hostile critics out of all proportion to their bearing on his arguments for utility. I think that, having opponents at every point, his proper course was not to commit himself to any more specific definition of happiness than his case absolutely required.

It was obviously necessary that he should give some explanation of happiness; and on his principles happiness must be resolved into pleasure and the absence of pain. Here, however, he had to encounter at once the common dislike to regarding pleasure as the sole object of desire and pursuit—"a doctrine worthy only of swine," to which its holders have both in ancient and in modern times been most profusely likened. He courageously faces the difficulty by pronouncing in favor of a difference in *kind* or *quality* among pleasures; which difference he expands through two or three eloquent pages, which I believe have received more attention from critics on the other side than all the rest of the book put together. My own decided opinion is, that he ought to have resolved all the so-called nobler or higher pleasures into the one single feature of including with the agent's pleasure the pleasure of others. This is the only position that a supporter of utility can hold to. There is a superiority attaching to some pleasures that are still exclusively self-regarding, namely, their amount as compared with the exhaustion of the nervous power; the pleasures of music and of scenery are higher than those of stimulating drugs. But the superiority that makes a distinction of *quality*, that rises clearly and effectually above the swinish level, is the superiority of the gratifications that take our fellow beings along with us; such are the pleasures of affection, of benevolence, of duty. To have met opponents upon this ground alone would have been the proper undertaking for the object Mill had in view. It surprises me that he has not ventured upon such a mode of resolving pleasures. He says, "On a question which is the best worth having of two pleasures, or which of two modes of existence is the most grateful to the feelings, *apart from its moral attributes and consequences*, the judgment of those who are qualified by knowledge of both must be admitted to be final." Apart from moral attributes and consequences, I do not see a difference of quality at all; and, when these are taken into account, the difference is sufficient to call forth any amount of admiring preference. A man's actions are noble if they arrest misery or diffuse happiness around him; they are not noble if they are not directly or indirectly altruistic; his pleasures are essentially of the swinish type.

Still rasher, I think, is his off-hand formula of a happy life,* if he meant that this was to be a stone in the building of a utilitarian philosophy. As a side-remark upon some of the important conditions of happiness, it is interesting enough, but far from being rounded or precise. It was only to be expected that this utterance should have the same fate as Paley's chapter on "Happiness," namely, to be analyzed to death, and its mangled remains exposed as a memento of the weakness of the philosophy that it is intended to support. It was clearly his business, in conducting a defense of utility, to avoid all questionable suppositions, and to be content with what everybody would allow on the matter of happiness.

His third chapter, treating of the "Ultimate Sanction of the Principle of Utility," has been much caviled at in detail, but is, I consider, a very admirable statement of the genesis of moral sentiment under all the various influences that are necessarily at work. Here occurs that fine passage on the social feelings of mankind which ought, I think, to have been the framework or setting of the whole chapter. Perhaps he should have avoided the word "sanction," so rigidly confined by Austin and the jurists to the penalty or punishment of wrong.

The real stress of the book lies in the last chapter, which is well reasoned in every way, and free from damaging admissions. Under the guise of an inquiry into the foundations of justice, he raises the

* Happiness was "not a life of rapture; but moments of such, in an existence made up of few and transitory pains, many and various pleasures, with a decided predominance of the active over the passive, and having, as the foundation of the whole, not to expect more from life than it is capable of bestowing."

question as to the source of duty or obligation, and meets the intuitionists point by point in a way that I need not particularize.

By far the best hostile criticism of the "Utilitarianism" that I am acquainted with is the posthumous volume of Professor John Grote. It will there be seen what havoc an acute, yet candid and respectful, opponent can make of his theories of happiness. Many of those strictures I consider unanswerable. Professor Grote also makes the most of Mill's somewhat exaggerated moral strain, and his affectation of holding happiness in contempt; "doing without it," if need be.

It was in 1860 that he wrote his volume on "Representative Government." The state of the Reform question, which led him to prepare his pamphlet on Reform, was the motive of the still larger undertaking, his principal contribution to a Philosophy of Politics. He says in the preface, that the chief novelty of the volume is the bringing together, in a connected form, the various political doctrines that he had at various times given expression to; but the mere fact of viewing them in connection necessarily improved their statement and bearings; and the six or eight months' additional elaboration in his fertile brain could not but infuse additional freshness into the subject.

In my estimate of Mill's genius, he was first of all a logician, and next a social philosopher or politician. The "Political Economy" and the "Representative Government" constitute his political outcome. People will differ as to his political conclusions, but certainly any man that wishes to judge of any matter within the scope of the "Representative Government" should first see what is there said upon it; and the work must long enter into the education of the higher class of politicians. The chapter on the "Criterion of a Good Form of Government" contains an exceedingly pertinent discussion of the relation between order and progress; and demonstrates that order can not be permanent without progress: a position in advance of Comte. The third chapter demolishes the fond theory entertained by many in the present day, that the best government is "absolute authority in good hands." Then comes a question that needs all the author's delicacy, tact, and resource, "Under what conditions is representative government applicable?" But his strongest point throughout is the exposition of the dangers and difficulties attending on democracy. This was one of his oldest themes in the "Westminster Review"; he has put it in every possible light, and discussed with apostolic ardor all the contrivances for withstanding the tyranny of the majority. He took up with avidity Mr. Hare's scheme of representation, and never ceased to urge it as the greatest known improvement that representative institutions are susceptible of. He dismisses second Chambers as wholly inadequate to the purpose in view, however useful otherwise. The discussions on the proper functions of the local governing bodies, on dependencies, and on federations, are all brimful of good political thinking. He passes by the subject of hereditary monarchy. Both he and Grote were republicans in principle, but they regarded the monarchy as preferable to the exposing of the highest dignity of the state to competition. From my latest conversations with Mill, I think he coincided in the view that simple cabinet government would be the natural substitute for monarchy.

It was in 1861 that he turned his thoughts to a review of Hamilton's "Philosophy." Writing to me in November, he says, "I mean to take up Sir William Hamilton, and try if I can make an article on him for the 'Westminster.'" He chose the "Westminster" when he wanted free room for his elbow. He soon abandoned the idea of an article. In December he said: "I have now studied all Sir W. Hamilton's works pretty thoroughly, and see my way to most of what I have got to say respecting him. But I have given up the idea of doing it in anything less than a volume. The great recommendation of this project is, that it will enable me to supply what was prudently left deficient in the 'Logic,' and to do the kind of service which I am capable of to rational psychology, namely, to its 'Polemik.'"

He was interrupted for a time by the events in America. In January, 1862, he wrote his paper on the civil war in "Fraser." He expected it to give great offense, and to be the most hazardous thing for his influence that he had yet done.

After spending the summer in a tour in Greece and Asia Minor, he wrote again on the American question, in a review of Cairnes's book in the "Westminster." This done, he set to the "Hamilton," which was the chief part of his occupation for the next two years. His interruptions were the article on John Austin in the "Edinburgh," in October, 1863, the two articles on Comte in the end of 1864, and the revision of the "Political Economy."

I had a great deal of correspondence with him while he was engaged with Hamilton. He read all Hamilton's writings three times over, and all the books that he thought in any way related to the subjects treated of. Among other things, he wrote me a long criticism of Ferrier's "Institutes." "I thought Ferrier's book quite *sui generis* when I first read it, and I think so more than ever after reading it again. His system is one of pure skepticism, very skillfully clothed in dogmatic language." He was much exercised upon the whole subject of indestructibility of force. His reading of Spencer, Tyndall, and others landed him in a host of difficulties, which I did what I could to clear up. His picture of Hamilton grew darker as he went on; chiefly from the increasing sense of his inconsistencies. He often wished that he was alive to answer for himself. "I was not prepared for the degree in which this complete acquaintance lowers my estimate of the man and of his speculations. I did not expect to find them a mass of contradictions. There is scarcely a point of importance on which he does not hold conflicting theories, or profess doctrines which suppose one theory while he himself holds another. It almost goes against me to write so complete a demolition of a brother philosopher after he is dead, not having done it while he was alive."

During my stay in London in the summer of 1864, he showed me the finished MS. of a large part of the book. I offered a variety of minor suggestions, and he completed the work for the press the same autumn.

Of the many topics comprised in the volume, I shall advert only to one or two of the principal. After following Hamilton's theories through ten chapters, he advances his own positive view of the belief in an external world. Having myself gone over the same ground, I wish to remark on what is peculiar in his treatment of the question.

I give him full credit for his uncompromising idealism, and for his varied and forcible exposition of it. In this respect he has contributed to educate the thinking public in what I regard as the truth. But in looking at his analysis in detail, while I admit he has seized the more important things, I do not exactly agree with him either as to the order of statement or as to the relative stress put upon the various elements of the object and subject distinction.

In the first place, I would remark on the omission of the quality of "Resistance," and of the muscular energies as a whole, from his delineation of the object or external world. In this particular, usage and authority are against him to begin with. The connection of an external world with the primary qualities has been so long prevalent that there must be some reason or plausibility in it. His own father and Mansel are equally emphatic in setting forth resistance as the primary fact of externality. Mill himself, however, allows no place for resistance in his psychological theory. In a separate chapter on the "Primary Qualities of Matter," he deals with extension and resistance as products of muscular sensibility, and as giving us our notions of matter, but he thinks that simple tactile sensibility mingles with resistance, and plays as great a part as the purely muscular ingredient; thus frittering away the supposed antithesis of muscular energy and passive sensibility. Now, for my own part, I incline to the usage and opinion of our predecessors in putting forward the contrast of active energy and passive feeling as an important constituent of the subject and object distinction; and, if it is to be admitted at all, I am disposed to begin with it, instead of putting it last as Mr. Spencer does, or leaving it out as Mill does. It does not give all that is implied in matter, but it gives the nucleus of the composite feeling as well as the fundamental and defining attribute.

The stress of Mill's exposition rests on the *fixity of order* in our sensations leading to a constancy of recurrence, and a belief in that constancy going the length of assuming independent existence. Although he shows a perfect mastery of his position, I do not consider that he has done entire justice to it from not carrying along with him the contrast of the objective and the subjective—the sensation and the idea. Indeed, the exposition is too short for the theme; the reader is apt to be satisfied with the portable phrase "permanent possibility of sensation," which helps him to one vital part of the case, but does not amount to a satisfactory equivalent for an external and independent world. There would have been more help in an expression dwelling upon the "common to all," in contrast with the "special to me," to use one of Ferrier's forms of phraseology. This ground of distinction is not left unnoticed by Mill, but it is simply mentioned.

His chapter on the application to our belief in the permanent existence of mind is, I think, even more subtile than the preceding on matter. The manner of disposing of Reid's difficulty about the existence of his fellow creatures is everything that I could wish. It is when, in the concluding paragraph, he lays down as final and inexplicable the belief in memory, that I am unable to agree with him. This position of his has been much dwelt upon by the thinkers opposed to him. It makes him appear, after all, to be a transcendentalist like themselves, differing only in degree. For myself, I never could see where his difficulty lay, or what moved him to say that the belief in memory is incomprehensible or essentially irresolvable. The precise nature of belief is no doubt invested with very peculiar delicacy, but whenever it shall be cleared up it may very fairly be capable of accounting for the belief that a certain state now past as a sensation, but present as an idea, was once a sensation, and is not a mere product of thought or imagination. —(*Cf.* "The Emotions and the Will," third edition, p. 532.)

I may make a passing observation on the chapter specially devoted to Mansel's "Limits of Religious Thought." It is a considerable digression in a work devoted to Hamilton, but Mansel's book touched Mill to the quick; in private, he called it a "loathsome" book. His combined argumentative and passionate style rises to its utmost height. Mansel sarcastically described his famous climax—"to hell I will go" —as an exhibition of taste and temper. That passage was scarcely what Grote called it, a Promethean defiance of Jove, inasmuch as the fear of hell never had a place in Mill's bosom; it was the strength of his feelings coining the strongest attainable image to give them vent.*

Mill could not help adverting to Hamilton's very strong and paradoxical assertions about free-will; but, as he never elaborates a consecutive exposition of the question, I doubt the propriety of making these assertions a text for discussing it at full. Mill's chapter is either too much or too little; too much as regards his author, too little as regards the subject. The connection of punishment with free-will should be allowed only under protest; the legitimacy and the limits of punishment make a distinct inquiry. Punishment, psychologically viewed, assumes that men recoil from pain; there may be other springs of ac-

* Grote thought that the phrase was an echo of something occurring in Ben Jonson, where a military captain's implicit obedience is crowned by the illustration, "Tell him to go to hell, to hell he will go."

tion besides pain or pleasure; but, as regards such, both reward and punishment are irrelevant. I think Mill very successful in illustrating the independence of moral good and evil on the question of the will. He is not too strong in his remonstrance against Hamilton's attempt to frighten people into free-will by declaring that the existence of the Creator hangs upon it. It was quite in Hamilton's way to destroy all the other arguments in favor of a doctrine that he espoused, in order to give freer course to his own. He damages the advocacy of free-will by his slashing antinomy of the two contrary doctrines. It is certainly a clearing of the ground, if nothing more, to affirm, as he does so strongly, that "a determination by motives can not escape from necessitation." Such admissions give an opponent some advantage, but only as respects him individually. The general controversy, however, must proceed on different lines from his, and hence the waste of strength in following his lead.

Hamilton's attack on the study of mathematics was a battery of learned quotations brought out to confound Whewell and Cambridge. It is not very convincing; it hardly even does what Mill thinks toleration of hostile criticism tends to do, namely, bring out the half-truth neglected by the other side. It was not worth while to write so long a chapter in reply; but Mill, partly from what he learned from Comte, and partly from his own logical studies, had a pat answer to every one of Hamilton's points. Most notable, in my view, is the paragraph about the disastrous influence of the mathematical method of Descartes in all subsequent speculation. He seems there to say that the *a priori* spirit has been chiefly kept up by the example of mathematics. Now, I freely admit that the axioms of mathematics have been the favorite illustration of intuition; but there is no certainty that, in the absence of that example, intuitionism would not have had its full swing during the last two centuries. Mill admits that the crudity of Bacon's inductive canons had an equally bad effect on English speculation; but all this shows simply that error is the parent of error.

The two subjects taken up while the "Hamilton" was still in hand —John Austin and Comte—deserve to be ranked among the best of his minor compositions. The "Austin" article took him back to his early days when he worked with Bentham and attended the lectures of Austin at University College. It does not seem to contain much originality, but it is a logical treat. The two "Comte" articles are still more valuable, as being Mill's contribution to the elucidation of Comte's philosophy. It will be long ere an equally searching and dispassionate estimate of Comte be given to the world; indeed, no one can again combine the same qualifications for the work.

IMPERFECTIONS OF MODERN HARMONY.

By S. AUSTEN PEARCE, Mus. D., Oxon.

THE works of Helmholtz, and those of his English translator Ellis, have drawn attention to the fact that piano-fortes and instruments with similar key-boards are out of tune. The recent contribution to musical literature by Professor Pole having referred to the subject of intonation, it becomes a duty to the public to point out the misconceptions of these theorists, and to state that musical problems are far more complex than they believe.

Although professing to work scientifically, they allow their senses to deceive them. Professor Helmholtz in his elaborate work "On the Sensations of Tone as a Physiological Basis for the Theory of Music," says, for instance, "We often hear four musical amateurs, who have practiced much together, singing quartets in perfectly just intonation." He is deceived in this. It is a popular error that music for stringed instruments or for voices is or can be rendered in tune; and scientists writing upon the subject invariably cling to this fallacy.

An unaccompanied quartet of singers returning at the close to the exact pitch at which they began would thus most certainly prove that they had sung out of tune. This is a startling fact—stranger than the current fiction—and demands complete demonstration. The subject is abstruse, and difficult to present clearly to persons not practically acquainted with the points at issue, but for the benefit of all thoughtful readers the attempt is made.

All the great Oriental nations of antiquity were familiar with the difficulties to be overcome in establishing a tonal system. The results of their experiments are known to the musical historian. It is sufficient to say that the necessity of accurate definition was universally desired in the earliest ages of which we have any record by peoples who did not employ harmony. But our own use of chords makes questions of intonation much more intricate. We not only require a song or melody, but several songs or melodies to be given simultaneously, as in the ordinary church quartet or fugal chorus, where each singer demands the right to be provided with some important subject-matter, worthy the delivery of a feeling, acting, willing spirit—some "part" which fully occupies him. He will not be content with a mere accompaniment to some leading part. The harmonizing of these several melodies, that they may at every instant make recognized and well-proportioned combinations called chords, constitutes the modern science of harmony. This science is based upon the comparatively recent discoveries that Nature herself supplies a full chord, or *cortége* of harmonic sounds, to attend every single note, and others also to attend a union of two notes, and so on. The ancient Greeks, not being acquainted with these natural products, and misapplying certain mathematical laws, failed to obtain concords sufficiently true to satisfy their refined artistic perceptions, and therefore rejected them. The modern pagan nations, even those competent to produce perfect concords, refuse to adopt them; and therefore our modern harmony still remains either unknown or unappreciated outside Christendom. It may be that we are generally regarded in the East as Western barbarians. The Chinese, for instance, smile at the piano-forte as an ingeniously contrived arrangement for enabling the performer to produce many different sounds at once as required by Western harmony; but as a mere mechanical instrument, in which hammers are thrown against strings in an inartistic manner, illustrative of our insensibility. They formulate thirty-three ways of plucking a string with the finger, and therefore are more fastidious than ourselves respecting "touch" and the corresponding delicate variations of tone due to different modes of vibration.

It is quite evident that Eastern peoples have cultivated their perceptions in departments of musical art of which we are comparatively regardless, and it is fair to assume that they reject our harmony because of its inherent imperfections. The extremely sensitive ear of the ancient Hindoos, observed by all students of Sanskrit poetry, led them to make, in common with the Persians and modern Arabians, finer distinctions than we recognize in the musical scale. And it is certainly true that even our natural perceptions of perfect consonance are rendered less acute by habitually listening to and accepting as true harmonies that are systematically rendered untrue, and so far rough and discordant in conformity with our adopted scheme of slight deviations from strict accuracy.

Helmholtz directs us to remain satisfied no longer with this condition of things, and demands that our music be rendered in tune. Those writers who follow the lead of this great physicist take up this cry in common with others, and assume to teach musicians their art. Instrumentalists are advised to construct instruments having twenty-four, twenty-eight, thirty, forty, or more sounds within the octave, instead of allowing the ordinary twelve—the seven white and five black keys of the manual—to do duty for the whole. It is deliberately proposed that three rows of keys be provided, that a simple hymn-tune may be correctly rendered. Mr. Ellis thinks that a fourth or fifth organ or harmonium should be at hand to be used for exceptionally brilliant and novel combinations. Similar recommendations have often been made before. They are useless. For such instruments would be found too complicated for general artistic purposes, and yet would not be elaborate enough to obtain the desired perfection, because this is unattainable. It is unattainable, not on account of the incapacity of the musician, but from the nature of the case. It is impossible to unite melody and modern harmony, and retain for either its just proportions; nor can we set one or the other aside. No such sweeping change can be made in the art by the mere musician. He can not compose music worthy the attention of the world, under the direction of any theorist, interested only in some one principle of truth ; nor can he greatly alter the character of his productions.

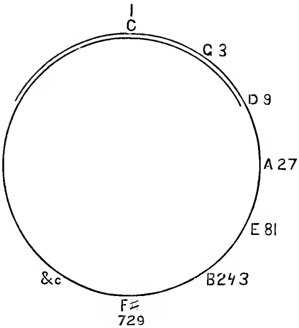
The composer is the child of his time and nation, and can not free himself from the conditions under which he works. Yet he obeys a blind necessity no more than other men, equally powerless to turn back the tide of modern civilization. It proceeds by virtue of a force which is incontrollable, and at most can only be slightly diverted. Music is one of its art-products. It broke in upon the darkness of mediæval ages, and was a factor in the general illumination that dispelled the gloom, when the Western world arose refreshed as from a deep sleep. It appealed to the sense of hearing—the last to sink to rest, always the first to awaken.

Counterpoint and the science of harmony aided in the formation of this new art, which has earned the distinction of being recognized as the only classic art of the nineteenth century. It is a glorious fabric, and will endure, although scientific purists wish it to be destroyed and another one erected in its stead on the principles of abstract truth. They propound a destructive theory, and yet give no practicable mode of procedure. They do not even remove difficulties to be overcome at the very outset. The musician is invited to attempt the impossible, namely, to make equal things that are unequal—to make the melodic scale agree with the harmonic scale, their proportions being dissimilar. He is compelled to make compromises, either acknowledged and defined, as in the systems of tuning piano-fortes, or unacknowledged and undefined, as in performances on violins. In no other manner can he proceed.

It would be easy for him to employ a few simple chords with the most perfect proportions, but he is required to produce a long-extended and complicated web of harmony—some thousands of combinations in a symphony or other similar work of art. It would be still easier for him to present chords singly as isolated columns, that they may be contemplated "as they stand"—each resting on a fundamental base or bass ; but he must exhibit them connectedly—"as they move." Only by passing on and on, from chord to chord in ever-changing forms, from sweetest consonance to most brilliant dissonance, from exciting successions and combinations to calming ones, is harmonic texture provided for musical compositions. Sometimes, also, the melody remains unchanged when the harmonies are greatly altered, so that its expression may be varied, as the features of the same countenance may express varied emotions, and yet be always recognized.

Similarly, architectural purists, previous to the year 1837, made perfectly cylindrical columns, straight lines, and plane surfaces, and, proceeding to build on these principles of truth, made imitations of Greek art that are regarded with indifference in London, Paris, and Berlin. The Parthenon and Theseum were to be contemplated as wholes, and therefore all apparently straight lines and plane surfaces were made respectively curved and convex, that the effect might be smoother—less hard and dry. There are, however, these notable differences in the two cases: It was possible for the architectural purist to make line meet line, but for the musician it would prove impossible. For he, working in a tonal system that is a slowly ascending infinite spiral, can not make his lines return into themselves without making delicate modifications.

Whichever way he proceeds he is led out into infinity;* but, without passing the fourth step, he is compelled to make modifications to reconcile melody with harmony. And whereas the Greek architects made slight variations from abstract truth that the effect on the beholder might be heightened, knowing well the peculiarities of the human eye, the musician trusts in the inability of the ear to detect the modifications he is bound to make, and which he hides with subtile devices.



Five modes of proceeding are now to be exemplified to prove that it is impossible to observe just proportions, and that the course taken by musicians is the best known:

1. The errors may be acknowledged and defined, by the employment of some one fixed "temperament," to determine the nature and extent of the deviations. Whether this be Pythagorean or Helmholtzian, cyclic or non-cyclic, skhismo-cyclic or mesotonic, equal or unequal, it will have as a matter of course its own peculiar inherent imperfections. The "equal" temperament is the one universally employed now for piano-fortes and organs.

2. The errors may be unacknowledged and undefined. In such cases all is left to chance or vague feeling, and the performance may be an ignorant floundering in an open sea of tone, rather than the mathematically accurate rendering as supposed by Helmholtz in the quotation given above. It is true that performers who have practiced long together, who sympathize with one another and with the aims of the composer, and who are deeply imbued with the spirit of his work, give artistically good renderings. The soul-state recorded by the composer is impressed upon the auditors. This is the purport of the music, and nothing more seems desired. It transcends all formal, cold measure-

* See article on "The Modern Piano-forte" in "Popular Science Monthly" for October, 1877, p. 701.

ments. If the performers tried to be true to these, the gist of the story, as it were, would be lost in the telling. The performance, therefore, may be psychologically true and yet mathematically false. There is a natural tendency to raise notes under the influence of extremely excited, passionate phrases and to depress them in sinking to a state of repose. But, irrespective of such changes, errors must certainly be made by singers and violinists of the nature of those now to be defined, however they may be glossed over and hidden.

Mr. Ellis illustrates his system of "Duodenes" by the first line of the hymn "My country, 'tis of thee," which is better known to German and Anglo-Saxon peoples as "God save the Queen." It will be employed here, for it is not only familiar and very simple, but usually has equally simple harmonies that may be conveniently illustrated with low numbers and a few fractions.

Whatever numbers may by chosen for convenience, the proper proportions of the melodic notes are 15 : 16 : 18. Those of the chords in columns 1, 4, 5, 6, are in the ratio of 4, 5, 6, and those in columns 2, 3 in the ratio of 10 : 12 : 15. It is understood that the doubling or halving any of these chordal numbers will merely represent the note in another octave, above or below, it will not change its character so as to affect the investigation.

3. When the melodic proportions are true, the chords are untrue.

1	2	3	4
C 48	C 48	D 54	B 45
G 36	A 40	A 40	G 36
E 30	E 30	F $32\frac{2}{5}$	D 27
C 24	A 20	D 27	G 18

At the third note of the melody the chord is out of proportion, for the interval D : A, 27 : 40, should be D : A, 27 : $40\frac{1}{2}$ to be in the required ratio of 2 : 3 or 10 : 15.

4. When the chords are true, the melody is temporarily out of proportion.

1	2	3	4	5	6
C 128	C′ $129\frac{3}{5}$	D 144	B 120	C 128	D 144
G 96	A′ 108	A′ 108	G 96	G 96	G 96
E 80	E′ 81	F $86\frac{2}{5}$	D 72	E 80	B 120
C 64	A′ 54	D 72	G 48	C 64	G 48

In this case the melody leaves the scale, but returns to it again, as shown by the notes marked (˙) which are raised. This method of altering the melody to obtain correct harmony is almost impossible to performers. It being understood that a note repeated or sustained is to be repeated or sustained at the same pitch, that it may become a pivot (ligature) for the harmonies to turn on, and form a standard of measurement. The errors would therefore more often be as follows:

5. When the chords are true, the melody is permanently out of proportion.

1	2	3	4	5	6
8 C $129\frac{3}{5}$	24 C $129\frac{3}{5}$	20 D 144	10 B 120	8 C 128	12 D 144
6 G $97\frac{1}{5}$	20 A 108–	–15 A 108	8 G 96—	—6 G 96—	—8 G 96
5 E 81—	–15 E 81	12 F $86\frac{2}{5}$	6 D 72	5 E 80	5 B 60
4 C $64\frac{4}{5}$	10 A 54	10 D 72	4 G 48	4 C 64	4 G 48

Here the ratios of each chord are prefixed to the letters, representing the musical notes, that the harmonies may be readily verified. At the fifth chord the key-note is seen at once to be changed, and the melody therefore to be untrue. Viewed vertically, all is correct; viewed horizontally, errors appear in all four lines. Such music can not be made correct from both points of view.

No idea is more firmly rooted in the minds of musicians than that of a fixed key-note. Whenever the pitch is changed the belief is universal that the chords have been out of tune. Even Helmholtz and other scientists are unaware of the fact that perfect harmony requires a moving key-note. It will probably surprise them as much as it would have surprised Ptolemy Philadelphus to learn that the sun is moving in the direction of the constellation Hercules.

For the solar system to be, as it were, in tune, the sun must move; for the harmonic system to be in tune, the key-note must move. In the last illustration the pitch of the key-note (C) was depressed in the ratio of $129\frac{3}{5}$: 128. There would be three such depressions made in the first half of the melody, and by the same chords. There is no method by which the sum of the errors made in this direction may be atoned for by errors in the opposite direction. If, on repeating this half, the composer were to adopt the following harmonies, the key-note (C) would rise in the ratio of 63 : 64.

1	2	3	4	5	6
C 252—	-C 252	D 288	B 240	C 256	D 288
G 189	F-sharp 180	F-sharp 180	G 192 —	—G 192-	—G 192
E 157½	D 144	C 126	D 144	E 160	B 120
C 126	A 108	D 144	G 96	C 128	G 96

After exploring the whole known field of harmony, and calculating the elevations and depressions consequent on using more elaborate chords, it is asserted that the exact pitch could not be regained.

The formulated results need not be stated here; it is sufficient to give the conclusions to which they point. But assuming that the composer could succeed in so planning his chords that the second half of this melody would so correct the eccentricities of the key-note in the first half that at its completion the composition would be rounded off at the true pitch, it is easy to see that if the first strain were repeated, and the second left unrepeated, or any such ordinary change made, all his elaborate calculations would be of no avail.

Mr. Ellis, who proposes a system with 117 notes within the octave, is thus shown that an infinite number of notes is required, for there is no synonymity in any system when the key-note moves. At each change of pitch the whole series is changed. Mr. Bosanquet, with 53 notes to the octave, offers to provide musicians with materials for 84 scales; and thus we are more reminded of the musical formulæ of the ancient Hindoos—their 16,000 keys—than informed how the above simple melody may be correctly rendered.

It is somewhat amusing to find Mr. Ellis seriously proposing to employ three harmoniums, the three players having to touch the notes that happen to fall to their respective instruments, not only because, as shown above, the music would still be out of tune, but because no performer would play a complete melody by himself, but a note here, another there, unconnectedly. For, however neatly this might be managed, expression or artistic rendering would be unattainable. Yet it is remarked, "The performers would merely require a little drilling and practice together."

Logarithms may be piled and compiled to define scales, but it is not so easy to reconcile the conflicting principles that appear in actual composition. The musician baffles the mathematician, who fails to follow him in his operations, as proved by the hitherto unnoticed discrepancies between melodic and harmonic proportions herein demonstrated. Although the composer's notation is not an exact statement, the performers do not experience practical difficulties: the intention is known, and the intonation is made as perfect as may be, according to the nature of the instruments employed.

The method of tuning the piano-forte may be stigmatized as reducing music to a mere game of permutations and combinations of twelve tones, but no better method is offered by mathematicians and physicists, whose schemes for music prove them more visionary than musicians themselves, who within the limits of their art must be acknowledged to be practical. They are art-workers as a rule, not talkers. Writers on music are generally amateurs, occupied with some one principle, apparently forgetful of the fact that many principles have to be regarded in the production of an art-work—sometimes one, sometimes another having the ascendancy. Therefore, false ideas readily gain currency, for the public can more easily comprehend one or two ideas, put forth with literary skill, than a multiplicity of considerations requiring technical definition, and only correctly estimated by persons practically acquainted with their relative value. Well-written treatises on the plastic arts are frequently found suited to the use of the public, engraved illustrations being more immediately understood than musical quotations, for comparatively few persons can read, and imagine in silence, written harmonies. And, besides, the forms being original, neither geometrical nor taken from nature, no appeal to experience can be made.

Music appears as something quite apart, as though it held aloof from the realities of daily life. Yet, on closer inspection, it is seen to be connected so closely with art and life as to make its classification difficult.

Its rhythmic forms transcend any found in poetry and dancing. Its melodies are not merely grammatically correct constructions, but are felicitous expressions of the highest kind of rhetorical eloquence, which spring up as happy thoughts, and may endure from age to age with wonderful vitality as the national songs of a whole people. It is not merely dramatic, it is preëminently dramatic, many parts being employed not only consecutively but simultaneously. It simulates the gestures indicated in sculptured groups, not as fixed, but in motion, and with such ability as to create in some persons an almost irresistible desire to make corresponding movements. Its forms are original and independent of words, and are not copied like those of painting, which is still dependent on drawing.

It not only resembles Gothic architecture, in the sense of parts depending upon parts for the stability of the whole, so that a cathedral may be aptly spoken of as "petrified music,"; but is more like celestial architecture, in which the base is not an immovable foundation, but moves itself; and, in the due observance of distances (intervals) and speeds (time), the balance is preserved—as, for instance, in the choruses of Bach and Handel.

Its science of acoustics allies it with optics. It can be expressed in algebraic terms or simple numbers, as the above illustrations prove. It transfigures the spoken word in song. For its performance gymnastic exercises are required. Its expressions are like words, in being either conventional or imitative, or partly both ; and, unlike words, in that their meaning can not change. It does not describe soul-states or cause their formation after reflection, like poetry, but reveals and induces them immediately, and so surely that Beethoven's sonatas are so many psychologic records.

The composer is more bound by natural laws than other artists, and yet is so free that his productions more nearly resemble actual creations. Music, in its threefold nature, appeals to man in his threefold nature. With great splendor of manifestation an orchestra engages the ear, and sometimes powerfully affects the nervous system ; whatever is surveyable in the music occupies the intellect, and its signification affects the soul. It is not so much art-calculated as science-inspired.

Here is ample evidence that a mere "physiological basis" is insufficient for the artist, and the advice that he should form a new art, less dependent upon gorgeous harmonies, is equally futile. For, although a composer exercises greater power over music than the philologist over language (who can only explain and classify roots already existing, being powerless to provide a new one), yet still the course of music is propelled by forces that can not be long or successfully opposed. No one affects to believe that steam, electricity, etc., will be set aside at the bidding of Mr. Ruskin.

Modern compositions are the natural expression of our time. Even the music of Mozart and Haydn seems to be truly Arcadian, compared with that of Beethoven and Schumann. It is comparatively artless, cheerful, and free from sighs. The works of these later writers rise to loftier heights and sink to deeper depths, reveling in a larger scale of human passion than those of their predecessors. Here aspirations, longings, strivings, are portrayed with a vividness that mirrors the spirit of the age. This music is not, like Tennyson's "Sleeping Beauty," "a perfect form in perfect rest," but is as in a state of evolution. It wears not so much the expression of Raphael's Madonnas—of the peaceful faith of the cloister—as that of strong, earnest men, exercised with honest doubts in the battle of the creeds. We can not turn back, or remain still ; the cry is "Onward !" and, for good or for evil, we must proceed. Our art, side by side with the civilization it represents, will continue to grow, and then perhaps begin to decay, and finally give place to another still more glorious.

DAYLIGHT IN THE SCHOOLROOM.

By M. JAVAL.

WE are all agreed in preferring the light of day to any other. In spite of the extreme variations which take place in its intensity and sometimes in its coloring, we seldom think of modifying it or softening it for healthy eyes except when they are exposed to entirely unaccustomed conditions. The eye is capable of accommodating itself to most astonishing changes in the brightness of light. The light of the sun is about a million times more intense than that of the full moon; yet the eye can distinguish objects by the light of a star. The changes in the diameter of the pupil contribute only in a small degree to the faculty of adaptation, for, between the extreme dilatation and contraction of the iris, the sensitive surface does not vary in a greater proportion than that of one to a hundred. The power resides chiefly in the retina, the sensibility of which is blunted in daylight and intensified in darkness. In consequence of this remarkable aptitude, the eye is the reverse of a good photometric apparatus. Enormous changes in the intensity of light pass unperceived by it, and we are able to attend to our occupations undisturbed by the fluctuations which are constantly taking place.

Still, we must not demand of our organs the maximum of adaptation of which they are susceptible. If we read a book with the sun shining directly upon it, even if we do not injure the eyesight, we will disarrange the rate of adaptation, so that we will not be able for some time to see in a demi-obscurity. On the other hand, if we stay long in the dark, we may increase the sensibility of the retina so that a sudden return to daylight will be painful. Bearing these facts in mind, we should keep the direct rays of the sun out from workshops and schoolrooms, where the place of each person is fixed, and should not make our bedrooms too dark, lest the eye be worried by sudden changes. On a similar principle, we should flood with diffused light the rooms in which numerous workmen are to be gathered, some of whom must be far from the windows. With a good light, or one which is equivalent to several million candles a yard off, we use in reading only a fraction of the cornea, and the contraction of the pupil has the effect of greatly diminishing the diameter of the circles of diffusion which are liable to produce in the retina faults of vision. Under these conditions, a badly formed eye may perform good service, and is subject to only a moderate degree of fatigue. The brilliancy of the light may vary greatly without our losing the benefit of the clearness which an extreme contraction of the pupil assures. But as the day declines and the image on the retina becomes insufficiently luminous for clear vision, the pupil becomes dilated, and the inequalities of different eyes are manifested. The diminution of light goes on almost unnoticed by well-formed eyes, for it is compensated by the increase of the used surface of the cornea. Less perfect eyes, on the other hand, not being able to perform their functions with ease, have to make fatiguing efforts to accommodate themselves to the situation, which tend to increase existing defects or to induce short-sightedness.

Adults are less liable than children to suffer injury from insufficient light, for several reasons: 1. Their pupils being less dilatable, they are obliged to desist from their work sooner when the light diminishes; 2. They make more frequent use of glasses; 3. They are less often confined, like school-children, and compelled to continue their labors after the light has become insufficient; and, 4. The coverings of their eyes are less extensible, and, if they have so far escaped myopia, they have more chances of continuing free from it.

A good management of the daylight is especially important with regard to the construction of schoolhouses. It is not enough to lay down a rule establishing the proportion which the surface of glass should bear to the number of pupils; attention must also be given to the direction whence the light comes to each pupil. The darkest point in the room must be light enough, and for this it is necessary that each desk shall receive a sufficiency of light direct from the sky. Every one who has practiced photography knows that the sky acts more strongly than any terrestrial body upon the sensitive surface. The least favored place in the room should be within the reach of this light. Nevertheless, the direct rays of the sun should be avoided, for they will dazzle. Where such an arrangement is otherwise practicable, the advantage of a diffused light may be gained by opening windows on the north side. Then, if the seats are placed perpendicularly to the wall occupied by the windows, so that the pupils may receive the light from the left side and from above, the result will be satisfactory provided the width of the room does not much exceed the height of the tops of the windows above the floor; for, under this condition, the least favored seat will still look upon about one twentieth of the surface of the sky. With ceilings of the ordinary height, unilateral lighting answers very well for rooms that do not exceed twelve or thirteen feet in width. For larger rooms, windows may also be opened on the other side, or behind the pupils, but never in front of them.

If we open windows in opposite sides of the room, we must arrange it so that they shall not be on the south side, for that would let in the glare of noon. For this reason it would be preferable to direct the axis of the room north and south, in which case it may be expedient to temper the forenoon and afternoon sunshine with transparent curtains. This arrangement will also give us the advantage of a better lighting in the morning and afternoon during the short days of winter. A certain latitude in orientation is admissible, which may extend to forty degrees on either side of the north and south line, as the disposition of the ground may require. An inclination toward the north-northeast is preferable to one toward the north-northwest for general hygienic reasons, for with it the room may receive the sun for the longer time in the forenoon. The teacher should face the south, so that the pupils facing the north may receive the stronger light from behind. In the northern part of the country a window might be allowed at the top of the southern wall, to be covered during sunshine and used during dark weather.

We have still to consider the possibility of the schoolroom being shadowed by neighboring buildings. This must be prevented by acquiring enough ground to keep the buildings away. Even after we have properly proportioned the height of the windows to the size of the room, if there is a neighboring building the height of which is precisely half the distance between its base and the middle of the schoolroom, the worst situated scholars will receive the light from only the upper half of the windows, and not enough of it. We have, then, to establish the rule that a free space must be reserved on either side of the schoolroom, the width of which, measuring from the middle of the room, shall not be less than twice the height of the largest building that is likely to be put up near it. The inconvenience arising from the shade of trees is modified by the absence of leaves in the winter and their welcome presence in summer, and does not call for general rules.—*Revue Scientifique.*

HYGIENE IN THE HIGHER EDUCATION OF WOMEN.

By A. HUGHES BENNETT, M.D.

AMONG the large and increasing flocks of patients who crowd the out-door departments of our metropolitan hospitals, there is a class of persons who of late years have rendered themselves conspicuous by demanding medical assistance. These are women who have to gain their livelihood by the exertion of their intellectual faculties, and who follow callings which require the constant exercise of their mental powers. An example of this is the so-called pupil-teacher, whose career we shall endeavor briefly to sketch. A young schoolgirl of about thirteen years of age is remarked to be unusually intelligent. It is suggested to her parents that she should become a teacher. They consenting, the child is at once placed under training. According to information derived from these pupils, the routine of life for the next six or seven years is as follows: They have—1. To continue their education, by receiving from others several hours of special instruction every day, and a considerable proportion of their evenings is spent in preparing themselves for this; 2. They themselves have to teach the younger children in the school for from five to six hours daily; 3. They have to pass a Government examination at the end of each year, which entails further special private study. This course of instruction continues for five years; and, being satisfactorily concluded, the pupil becomes an assistant teacher. During the next two years she either resides in a college and there undergoes a special and systematic course of study, or, if her means preclude, she continues the system already described at school, and further prepares herself for a final examination; after which, if she acquit herself in an efficient manner, she becomes a full teacher, and as such is certified by Government.

Such a career may be said to represent the intellectual life of an ordinary student, in which there are considerable mental strain, a constant exertion to acquire and retain knowledge, anxiety as to results, and possibly worry and irritation in details. In consequence, there are diminished exercise, loss of fresh air, and generally deficient hygienic surroundings. We have said that numbers of such young women are constantly applying to the hospitals for medical assistance. They complain of physical debility, anæmia, dyspepsia, and loss of appetite; their functions are disordered and irregular, and they present the usual conditions of bodily weakness and depression. Their nervous system and mental faculties are also affected. They are irritable, nervous, depressed, and melancholic; they do not sleep at night, partially lose their memories, they suffer from violent headaches, and can not settle to work; they have all kinds of nervous and subjective pains, hysterical symptoms, and, in short, all the phenomena of nervous and mental as well as of physical exhaustion and debility. If our patients be asked the cause of these ailments, they will with one accord say that it is the hard and constant brain-work, combined with worry and perpetual anxiety.

From teachers let us turn aside for a moment to women who follow other intellectual employments. If we examine the matter we shall find, a certain number of exceptions always being allowed, that as a rule when females are subjected to severe and prolonged mental exertion, more especially if it is associated with anxiety and physical fatigue, they break down under the ordeal. How many excellent and clever women have we known who, either from necessity or from love of study, have eagerly embraced and distinguished themselves in literary, scientific, and educational pursuits! Burning the midnight oil, contending, it may be, with difficulties, harassed with doubt and anxiety, debilitated from want of rest and bodily fatigue, they struggle on, their circumstances or their enthusiasm impelling them, but at last they, like the pupil-teachers, give way and succumb from sheer exhaustion. The objects of this paper are to endeavor to explain why this deterioration of health should so frequently take place in women when subjected to bodily and mental strain, in distinction from men, in whom, under the same circumstances, it is comparatively unusual; and, with the view of elucidating this, to discuss the physical and intellectual capacities of the sexes, and to ascertain whether, in these respects, the male and female are upon an equal footing. That these propositions may be rendered intelligible, some preliminary observations are necessary.

The Physical Conformation of Woman.—It will be generally conceded that woman is physically weaker and less powerfully built than man. With few exceptions, this distinction between the sexes is universal throughout the entire animal kingdom. From the lowest to the highest species, the general structure of the male differs from that of the female in the size and strength of his bones and muscles, the form of his head, thorax, and limbs, and in the possession of special weapons of offense and defense. In the human being, although this to a certain extent is modified by circumstances, the same general law holds good. Owing to his conformation, the man is capable of performing and of enduring more physical labor and fatigue, and hence on him, from time immemorial, has fallen the share of manual toil, and of supporting and protecting the other and weaker sex. It is true we sometimes meet with—

> "Daughters of the plow, stronger than men,
> Huge women blowzed with health, and wind, and rain,
> And labor."

Such, all will admit, are exceptions, and by no means represent the standard woman.

The generative organs form a most important distinction between the sexes, and must, to a great extent, modify the habits and career of the female. In the natural course of events, many years of the most vigorous and active period of a woman's life are spent in germinating and suckling her offspring, during which time she is physically capable of little else. If she has not children, frequently recurring periodic processes take place, which, under the best circumstances, render her specially liable to derangement of her general health, and under adverse conditions she is almost certain to fall a victim. This was demonstrated in the days of slavery, when the owners, either not knowing or caring about these physiological laws, forced their women to labor continuously in the fields, in consequence of which thousands of them died of those numerous ills to which female flesh is heir. We can not here enter at length into this very important subject, but merely indicate that the whole sexual system of woman has a profound influence on her physical nature, which does not exist to the same extent in man, and, although for conventional reasons such questions are usually suppressed in public controversies on the advancement of her sex, there can be no doubt that they should not be forgotten, having, as they do, a most important and practical influence on the subject.

From these considerations the conclusion may be drawn that woman is structurally less powerful and vigorous than man, that she is less capable of performing acts of physical exertion, of enduring fatigue and exposure, and of combating against adverse circumstances. That, moreover, the natural functions of her sex, when they do not actually incapacitate her from action, render her specially liable, under disturbing conditions, to deterioration of general health.

The Nervous Conformation of Woman.—The whole nervous system, in common with the other structures of the body, is smaller and less voluminous in the female than in the male. Its function is characterized by comparative weakness, as evidenced by great susceptibility and instability, and also by promptness in responding to all kinds of stimuli. In women there is less nervous capacity and vigor, diminished power of control, and a greater readiness to break down under physical and mental strain. It is notorious that the conditions termed nervous and hysterical are almost entirely confined to the female sex, in which they are extremely common. Every physician at a hospital who treats out-door patients knows that for every hundred men he prescribes for he is called upon to treat at least five hundred women. On the other hand, the male wards are always full, while many of the female beds may be vacant. This simply indicates that serious disease is most common in men, while trifling nervous ailments are almost universal in women. Most women are naturally so predisposed that, when subjected to fright, grief, anxiety, pain, and other such circumstances, they feel (in addition to the direct distressing effects) various remote subjective phenomena in the form of suffocations, spasms, bodily pains, fainting, convulsions, and a general liability to violent and explosive emotional demonstrations. If the causes are permanent their effects may become so, and deteriorate the general health, and there are thousands of women who are hopeless invalids, often for life, from conditions acting on their susceptible and mobile nervous systems, which in the other sex would have produced no appreciable results. There are, of course, in this as in other things, numerous exceptions to the general rule, many women having their natures much modified and approaching the male type, and in the same way there are some men who are of a nervous and hysterical temperament. We may, then, assert as a fact that the nervous system of the average woman is more susceptible and impressionable than that of the average man, that it is in consequence more readily unhinged by mental and physical distress or fatigue, and that when thus disordered it reacts upon the system, so as to cause permanent disease.

The Intellectual Conformation of Woman.—The cranium of woman is smaller than that of man. The weight of the average female brain has been estimated at from five to six ounces less than that of the average male brain, and a general inferiority in size exists at every period of life, from the new-born infant to old age. Not only has this comparative decrease in size been determined, but it has been ascertained that the female brain is relatively smaller than that of the male, as compared to the weight of her body, and researches on this subject have shown that, while the encephalon of the female is ten per cent. less in weight than that of the male, her total bodily weight is only eight per cent. less. The brains of different races vary greatly in size, but whether it be in the most highly civilized nations, or in the lowest savages, the encephalon of the female is always comparatively and relatively smaller than that of the male. These facts show that the difference in size and weight is obviously a fundamental sexual distinction, and not one which can be explained on the hypothesis that the educational advantages enjoyed either by the individual man or by the male sex generally, operating through a long series of generations, have stimulated the growth of the brain in one sex more than in the other. All other circumstances being alike, the size of the brain appears to bear a general relation to the mental power of the individual. There are doubtless exceptions to this rule, but unquestionably the general axiom holds good in large averages ; therefore, as the organ of intellect in the female is smaller and lighter than that in the male, we may fairly assume that it is less capable of such high and extended mental powers. It is justly stated that quality as well as quantity should be considered, but of this we can only judge by results, in which case it must also be conceded that women are at a disadvantage. This assumption, if it can not be anatomically demonstrated, is amply proved by facts. From the beginning of the world, as man has been characterized by his physical force as compared to woman, so has he been remarkable for his superiority of intellectual power. At every age, in every country and climate, and under every circumstance, we find that in the highest qualities of mind, of reason, judgment, genius, inventive power, capacity for acquiring and utilizing knowledge, man stands preëminent. It is true that there have been some noble and illustrious women who have proved themselves of the highest mental capacity, and who have risen to the first rank in various departments of intellectual culture, but it must be admitted that these are rare exceptions, and that even they in every particular have been enormously outnumbered and surpassed by men. It may then be reasoned that the female has hitherto not had the opportunities or education necessary to fit her to place herself on an equality with the other sex. This argument of itself proves that she has not been born with the mental force to assert her pretensions, for it can not be maintained that physical strength alone could have forced her into a secondary intellectual position. Besides, it is not so : for in literature, poetry, music, art, and in numerous other branches of study in which she has had as many if not more opportunities of perfecting herself than man, she has rarely proved his equal and never his superior.

The intellectual powers of woman not only differ in degree from those of man but also in character. Her mind participates with her physical constitution in being endowed with great sensibility, and hence her acuteness, perception, and tact. She seizes with rapidity objects which come before her, and observes by instinct an infinity of shades of meaning in details which might escape the most observant of men. She often arrives at conclusions with great celerity and adroitness, but then her results are as frequently wrong as right. Her perception is fine and penetrating rather than extended or profound. She readily occupies herself with small impressions and details, but is arrested there, being less capable of grasping general principles. Although her mind may thus embrace a variety of particulars, it is to little practical purpose, from an intellectual point of view, as she can not fix her attention on any idea or train of ideas for any length of time, and reason out a logical conclusion. Woman dislikes and avoids that hard work which requires long and profound meditation, her character being adverse to the study of abstract science. Her thoughts wander, she becomes impatient, and her too mobile imagination is unable to rivet the attention on the dry details of a practical subject. She enters with enthusiasm and often with unnecessary vigor at first into any new project, philanthropic, educational, or otherwise, but rarely carries it steadily out to a successful termination. Her opinions are formed by her feelings rather than by the operations of reason. Her forte is that species of knowledge which requires more tact than science, more vivacity than force, more imagination than judgment. Her chief moral philosophy is directed to the study of individuals and society, and the sagacity of a woman in acquiring traits of character and penetrating true motive is what the logic of a man rarely acquires. Wise women—the so-called blue-stocking—as a rule know nothing profoundly. Their natural acuteness of perception enables them to seize a number of details and isolated particulars, they fancy they understand them thoroughly, they confound theory with fact, the real difficulties they do not surmount, they can not fix the attention long and deeply, or persevere in overcoming obstructions, and they feel no pleasure in habits of profound meditation. They therefore remain with their acquired superficial knowledge, pass rapidly from one thing to another, and there only rest in their minds certain crude and incomplete notions, with which they are quite satisfied, and of which they make the most, but which in consequence lead to false and illogical conclusions.

These observations are not for the purpose of merely lauding one sex at the expense of the other, but for a definite practical object, as will subsequently be seen. They serve to indicate that the average woman has been by nature endowed with a brain and nervous system of inferior anatomical construction to that of man, and that in consequence her intellectual powers differ from his, both in degree and in character.

THE DISPOSITION OF WOMAN.—Voltaire has said, "le physique gouverne toujours le morale," which is strikingly illustrated by the present inquiry. In the lower animals there is a marked difference in the disposition and character of the sexes. The males are of a combative nature, and have a great tendency to fight. They are bolder, fiercer, and more untamable. The females have more highly exalted perceptive faculties, they are cautious, artful, and cunning, as is abundantly seen in the ingenious methods they adopt in the hiding and protecting of their young. These properties serve them to some extent in lieu of physical force, and they are altogether more gentle and more tractable in their nature. The same, in a different degree, is obvious in the human female. Every mother knows that a male infant is more troublesome to rear than a female. As children grow older the difference becomes more marked. The girl is less boisterous, willful, and imperious than the boy. She is more delicate, impressionable, and artful, pleased with attention, solicits admiration, and is readily moved to tears at suggestion of sorrow or pain. He courts danger, is bored with solicitude, and, more blunted or careless, laughs at what she weeps at. She, with her doll, already anticipates the gentle duties of maternity. He, with his sword and trumpet, mimics the glory of war. On the disposition of the fully-developed woman poets have written volumes. We, however, have to take a more matter-of-fact view of her than they have done. When Hamlet said, "Frailty, thy name is woman," he was scientifically correct, in more senses than he intended. Her natural muscular feebleness and delicacy of constitution render violent exercise and labor distasteful to her, and her inferiority of intellectual power makes severe and constant mental exertion a task. While the man, full of bodily and mental vigor, goes forth seeking and braving danger and labor, proud in the responsibility of those dependent on him, the woman fulfills a welcome task at home in the less active duties of matrimony, and of domestic and social observances, equally happy in the possession of a strong arm and head to protect and support her. Such an existence, however, fosters a great susceptibility of character in addition to her natural conformation. Hers is often a mixture of extreme happiness or of profound misery. She feels pain, grief, and anxiety acutely. To these she readily gives way, and as rapidly revives from their effects. Sensations of all kinds act on her powerfully. These she can not control, but exaggerates into extremes, and manifests by violent demonstrations. If she feels acutely it is not for long, her sentiments at the time being easily replaced by new ones, and her mental distress, if rapidly induced, is more poignant than deep. Woman is essentially impulsive and emotional; her sensitive and changeable nature is necessary for the part she has to play in life. She feels more than she thinks. A man forces his way by power of body and intelligence. She acts on him by tact and by all those weaknesses in which with him lies her chief power. Her flexibility of character gives rise to caprice which consists of a brusque passage from one sentiment to another totally opposed. Her habitual feebleness and deficient vigor inspire her with less confidence; and, as a woman can not therefore act directly, she employs indirect measures to effect her ends. Hence the natural desire to please inherent in the sex, the artfulness, the dissimulations, the little managements and intrigues, the graces, the coquetry, and other seductive ways, which, to a certain extent, have always been ceded to by intellectual and physical force. For the same reasons, and from the same cause, her weaknesses and vices are greater, and no man can compete with a really bad woman in petty jealousies, spiteful actions, revenge, and even in the ingenuity and vindictiveness of crime. It is this affectability which, if it be a cause of her frailties, is equally efficacious in giving luster to her virtues. It is this which constitutes the chief charm of the mother, who instinctively detects the slightest desire or change in her offspring and impulsively acts for its benefit; of the wife, who sympathizes with and encourages her husband, fagged and anxious for the common weal; and of the nurse, who takes in at a glance all the details and wants of the patient and ministers to his requirements with pity and devotion. It is this which gives rise to that compassion, sympathy, piety, and affectionate disposition which are the chief characteristics of a woman. It is the feeling of powerlessness which makes her identify herself with the unfortunate and unhappy, which natural pity is the base of all social virtues.

The Effects of Social Life and Education on Woman.—There can be little doubt that social manners, education, and an infinity of circumstances may affect the qualities woman derives from her material organization, and even efface the original character which nature has given her. In the simplest condition, the man labors with his hands and with his wits for mutual support and protection; the woman rears her children, tends the sick, and conducts domestic affairs. Such, if the most primitive, is probably the healthiest and happiest condition for the female. Her sympathetic and susceptible nature has here every scope for action without being shaken by rude and oft-repeated shocks. In civilized life, especially among the upper classes, everything seems combined to foster and increase the natural affectability of woman's nature, and society renders her, already unfortunate by organization, the victim of the most painful and varied series of moral and corporeal affections. Medical philosophers have declaimed, and will long continue to do so, in vain, against the whole system of the education and bringing up of women, which is directed solely to the purpose of making them personally attractive, and subsequently securing for them brilliant settlements for life, at the expense of their health. Much might be written on this subject; suffice it at present to state that the useless and insipid lives that most young ladies lead, the total want of an intelligent interest and occupation, and the unnatural and artificial existence pursued, are highly calculated to injuriously enhance that natural affectability with which she has been endowed. The system of fashionable boarding-schools, whose anxiety to render their pupils accomplished and fascinating at all costs results in a forced and at the same time imperfect training, combined with luxurious living, absence of exercise, and other healthy circumstances, tends to increase the irritability of the nervous system and to foster a precocious evolution of character. As this is increased, tone and energy are diminished. The girl returns from school a wayward, capricious, and hysterical young lady, weak and unstable in mind, habits, and pursuits. She enters into society, and there her whole mode of life further contributes to her unfortunate condition. The competitions, disappointed affection and vanity, the artificial excitements of balls, public entertainments, late hours, and all the frivolities and pleasures of fashion, tend in the same direction. The cultivation of music, poetry, novels, and other inflammatory literature nourish illusions contrary to the actual state of society. Her very dress seems made on purpose to interfere with the healthy function of her most vital organs, and to prevent the free play of muscular action essential to a sound constitution. Girls subjected to such a *régime*, when their minds and bodies should be guided in a totally opposite direction, have one order of faculties alone exercised, and these, predominating over the reasoning powers, cause a host of nervous, vaporous, hysterical, and hypochondriacal disorders. Thus women from their earliest days are constantly subjected to the yoke of prejudices, are under the necessity of a perpetual state of acting and deception, of dissembling their desires and real inclinations for the sake of propriety, of keeping to themselves the most powerful passions and the strongest propensities, and of feigning a calmness and indifference when they are devoured by a burning fire.

As to education, we have already pointed out the general unsatisfactory nature of the intellectual studies of most women. That idleness and the absence of suitable and substantial occupation for the mind which so commonly exists in the higher ranks of society are the sources of great evils no one will deny. For the frivolous and luxurious so-called duties of fashionable life, although exhausting and fatiguing, can not be said to constitute that healthy exercise of mind or body which is desirable for young women to stave off disease and maintain sound health. Study and occupation, at the same time positive, useful, and attractive, are the best correctives of an imagination ardent and disordered, of a nervous system susceptible and hypersensitive. These considerations being made patent, many women, with the impulse characteristic of their sex, have rushed to the opposite extreme. They wish females to receive the same education as males, and to compete with them in the intellectual struggle for existence. We have, however, seen that both the woman's body and mind are inferior in vigor and power to those of the man, and accordingly, if pitted against one another in a physical or mental race, she, to use a sporting phrase, would be heavily handicapped. She will not, as a rule, reach his standard, and, if she endeavors to do so, it will be at the expense of her health. The brain and nervous system, like other organs, if overworked, become the centers of activity, and are fatigued; this increases existing susceptibility, and hence arise symptoms of nervousness, hysteria, hypochondriasis, and insanity. These acting on the body produce emaciation and other diseases, the offspring of an exhausted constitution.

The conclusion, then, to be drawn from this section is that, in addition to the natural affectability of her character, this condition in woman is fostered and augmented by the artificial exigencies of civilized life; that, whereas idleness and want of occupation are the greatest sources of many diseases peculiar to the sex, the opposite extreme of mental strain is equally prejudicial.

We have endeavored, in the brief space allotted us, to point out the physical and intellectual capacities of woman, and in consequence the disposition and instincts which nature has implanted in her. This fundamental difference between the sexes, we have seen, is not due to education or special cultivation, but to a primary development of the system, each having those peculiarities best fitted for the part it has been born to fulfill. There can therefore be little doubt that the most natural and healthy condition for a woman is a properly assorted marriage, in which she has children, with whom she has useful and congenial occupation, and by whom all her sympathies and best instincts are developed. In modern times great and laudable efforts are being made to effect an improvement in the higher education of women, and, as there are many who either from choice or circumstances can not occupy that position which it is the pride of most to possess, a movement has been made whereby they may earn an independent livelihood by the exercise of their mental faculties. We are informed by energetic and doubtless well-meaning speakers from the platform, that women have hitherto been under subjection, that they should emancipate themselves, that their intellect is as good as if not better than that of men, and that they are as capable as men are of the highest mental culture, and of profiting and distinguishing themselves thereby. It is unquestionable that suitable occupation and education are of the highest importance to the well-being of women, and that all due encouragement should be given to those who endeavor to provide for them an intelligent interest in life. But in avoiding Scylla care must be taken not to drift into Charybdis. To say that the majority of women are fit to cope successfully with men in the intellectual world would, we believe, for the preceding reasons, be a most injurious doctrine, and lead to disastrous results. Our text, the pupil-teacher, is an example. A young girl, between the ages of fourteen and twenty-one, the most anxious and important period in her whole life, when her mental and physical constitution is undergoing development, is put under a severe intellectual strain. She is irritated and worried all day by teaching children, she is fatigued by hard study, and is rendered constantly anxious by the frequently recurring examinations on which her reputation, and it may be her living, depends. Such a career does not as a rule break down the young man, but in a large number of cases it completely unhinges the woman. She, in fact, is compelled to perform the work of a man without having his organic basis to depend on, and hence, as a consequence, her entire system suffers. So it is with women who follow other pursuits requiring severe mental application ; they age before their time, and finally succumb. It is true that men occasionally give way under the same ordeal, but these are comparatively the exception, and this is as often brought about by the assistance of other circumstances as by work alone. It is also a fact that there are some women who, overcoming all difficulties, have fully acquitted themselves of the highest mental exertions without injury, thus proving themselves to be of masculine capacity. Whether for these the Church, the bar, and physic are to throw open their arms, I leave for others to decide ; but that the majority of the sex would be benefited by a systematic encouragement to follow learned professions and other laborious callings, would be, we think, physiologically and practically an error.

How unmarried women who require to earn their living are to do so by the exercise of their intellectual faculties, is one of the great problems of the day, and by far too extensive a subject to discuss at present. Our aim has been to point out that in controversies on the question the medical aspect of the case is frequently lost sight of, and it is forgotten that, in the competition for life, woman is the weaker vessel, and liable to be broken when too roughly handled. Sage philosophers may speculate what ages may effect by evolution, but, taking woman as we find her, we believe that her welfare is to be consulted, not by encouraging her to take an independent position in life and by fostering a contempt for marriage, which is now the professed tendency of the strong-minded young lady, but by educating her in such a judicious and sensible manner as will make her a good wife, mother, and useful member of society, which is unfortunately not the inclination of the present age. If this were more systematically carried out, there would be fewer single women under the necessity of working for their own living ; the outcry in behalf of these unappropriated blessings would be modified, and on entering the marriage state, which is the happiest as well as the healthiest condition, they would place themselves in the position that it is intended by Nature they should occupy.

> " . . . . Seeing either sex alone
> Is half itself, and in true marriage lies
> Nor equal, nor unequal; each fulfills
> Defect in each, and always thought in thought,
> Purpose in purpose, will in will, they grow,
> The single pure and perfect animal,
> The two-celled heart beating with one full stroke
> Life."

Sanitary Record.

ARTESIAN WELLS AND THE GREAT SAHARA.

By Lieutenant SEATON SCHROEDER, U. S. N.

OF late years public attention has been somewhat drawn to the great North African Desert. Mainly instrumental in directing thither even the eyes and ears of idle curiosity have been the two plans for flooding portions of that region. Of these plans, the French and the English, the former has assumed the more definite shape, though both are the subject of scientific and practical inquiry.

It may be questioned if there is not another means of improvement, more gradual, perhaps, but more sure and in many ways superior to the creation of an inland sea—superior in point of economy, and more widely diffused as well as more lasting benefits. Although our knowledge of the geological and historical part of the Sahara, and of its constitution, hydrography, and climate, is scarcely extended enough to prophesy confidently as to its future, yet it may be advanced that, if the desert is extending and the population decreasing, it is greatly due to the bigotry, hostility, and laziness of the Saharan tribes. The one requisite is water, whence the projects of supplying that need from the ocean. Perhaps it may be obtained otherwise, in comparatively homœopathic doses it is true, but fresh, and in such manner as to bring about grander results.

That water is not wanting in the Sahara is proved by the wells dotted along the routes of caravans. These are very shallow, and the water they afford is generally brackish and muddy, showing that they only reached parasitic sources and not the main subterranean sheets; but they are only the hurried work of passing caravans, whose sole thought was to supply the needs of the moment and reach the oases where very old wells have been found having a depth of over two hundred and fifty feet. It is a curious fact, too, well attested, that the number of wells has been greatly reduced by the Saharans filling up many of them as a means of defense against dreaded invasion.

These wells date back to the time of the first relations between the blacks of Soodan and the various peoples of white race driven into the desert by successive invaders. Diodorus, a priest of Tarsus in the fourth century, speaking of the great oasis in the desert forty leagues from the Egyptian frontier, mentions it being irrigated, not by rivers nor by rains, but by springs that issue from the ground not spontaneously, nor in consequence of the rains sinking into the ground, but by great labor on the part of the inhabitants. Several wells alluded to by him have been cleared since 1849 by a French chemist, M. Ayme, who established alum-factories in two Egyptian oases. These old wells were fitted with a stone pear-shaped valve by which the issue could be regulated.

About the middle of the sixth century, Olympiodorus of Alexandria speaks of wells five hundred cubits deep. Arabian writers in the middle ages describe them in detail; their great historian, Ibn Khaldoun, speaking of the spouting wells of the Sahara, considers them "a miraculous fact."

The origin of these subterranean waters is now well known. The streams flowing down the southern slopes of the Atlas Mountains of Morocco, Algeria, and Tunis, and on all sides of the Tibesti, Hogar, and other Saharan mountains, quickly disappear through the sands. M. Vivien de Saint-Martin, in "Le Nord de l'Afrique dans l'antiquité," says that, "under the sandy crust through which the waters necessarily sink, layers of clay have been found everywhere at various depths underground, where sheets of water make actual rivers."

The natural question then arises as to what causes these streams; how the parched desert furnishes rivers? Rains are quite abundant on the summits of the mountains—so much so that, in winter especially, the streams attain considerable proportions. The Sahara experiences at times tremendous storms and torrents of rain that in a few moments cause violent freshets. Dr. Barth, in his "Reisen in Nord und Central Afrika," cites among others a deluge that he witnessed at Tintagoda in latitude 19°. In less than an hour after a heavy rainfall on the mountain a sheet of water was rushing by with such force as to carry away herds of cattle and uproot trees; it covered to a considerable depth the whole valley, over a mile broad. In "Les Touaregs du Nord," M. Duveyrier says: "I had occasion on the 30th of January, 1861, while at Oursel, at the foot of the Tasli Mountains, to observe the overflowing of one of the numerous torrents that descend from that mountain. The rapidity of the stream was a metre a second, and the water brought down such alluvia that afterward the Touaregs could sow cereals where before there had been no arable ground." Further on the same traveler says: "In the spring of 1862 a storm of rain falling on the southern slopes of the Ahaggar brought such quantities of water into the valleys of Idjeloudjal and Tarhit that a portion of the mountain was carried away. The action of the water was so rapid as to sweep away and destroy an entire tribe encamped at the opening of the valleys." Also: "Up to 1856, on the left bank of the Ouadi Titersin, there had been a line of downs called Arekka-n-Bodelka so high that camels had been unable to cross them. A freshet in the Ouadi came with such force as to sweep away the entire mass composing the downs."

As M. Duveyrier says, the alluvial deposits from the Saharan torrents are often extremely fertile. At Biskra, at the time of the French occupation of that place (1844), a layer two yards in thickness of a rich loam was found on an ancient pillar of Roman construction.

The existence of subterranean sheets of water being well demonstrated, and a rude example being set by the untaught natives, it only remained to follow that example on the grander scale made possible by the advancement of science, and determine what benefits could be derived from these hidden treasures. Dr. Maurin enunciated, "Dig an artesian well in the region of sands, and the sands will become fixed by vegetation, and a forest of palms will soon stand where there had been a moving plain." And his saying is well borne out by numerous facts. In 1872 an old marabout (Mussulman devotee or saint) dug a well, planted palm-trees, and established himself at a place now called Tendouf; in less than a year it had become an important commercial center!

The first attempt at boring an artesian well on Algerian soil was in the plain of Oran, on the 7th of December, 1844. It was fruitless, although carried to a depth of 322 feet. A second attempt was made on the 14th of May, 1845, at Arzeu, and was likewise given up at 580 feet. Some time after the occupation of Biskra, a boring was made there to 270 feet: no result. It seemed a hopeless task to find living water, although it was well known that many years before the Arabs had had artesian wells.

General Desvaux, however, commanding the subdivision of Batna, kept studying assiduously to find means of fertilizing the barren regions around him. The perusal of several works by Tournel, by Berbrugger, by Prax, as well as a memoir of M. Dubocq published in 1853, convinced him that boring was destined to play an important part in the solution of the problem that so occupied him. In 1854 he chanced to be on the summit of a sand-hill near his camp, and overlooking the entire oasis of Sidi Rached. He saw that luxuriant vegetation, and turning away was confronted by the sterile waste on the other side. More than ever struck by the contrast, he sent for the sheik and questioned him, and learned that all the northern wells had become filled in with sand, that the parasite waters prevented digging any more, and that the entire population, broken-hearted, were looking forward to leaving their homes. As soon as possible he communicated with Marshal Randon, Governor-General of Algeria, and was authorized by him to commence a systematic search for water in the Sahara.

His project was then twofold: 1. To dig new wells in the Oued Rhir, give new life to the oases then beginning to yield to the invading sterility, and so win the gratitude of their population: 2. To revive the sandy steppes between that river and Biskra, open the desert to commerce as far as Ouargla or possibly Touat, so that French troops or isolated travelers could enter that region without the fear of dying of thirst.

He experienced some delay, of course, but finally in 1856 the material arrived at Tamerna, and on the 1st of May of that year the first blow was struck by Ali-Bey, the Caid of Tuggurt. The work was pushed rapidly forward, and on the 9th of June water issued in volumes. Lieutenant Rose, of the French army, describes the scene as being most affecting, comparing it to the miracle of Moses drawing water from the rock by the touch of his rod; the old skeik prostrates himself, mothers bathe their children in it, and it is blessed and named the Fountain of Peace. The issue of water was 69,725 gallons a day, temperature of 70° Fahr.

The news spread like wildfire, and the commandant of the province of Constantine was besieged with petitions from other oases to do as well by them. In eight years, 1856 to 1864, the French Government established in that vicinity (between the Ziban oases and the river Rhir) seventy-two artesian wells, of which twenty-four had been previously abandoned in course of execution by the natives. They cost altogether 290,000 francs ($55,970), had an aggregate depth of boring of 11,106 feet and a total first issue of 17,600 gallons per minute. The deepest was at Chegga, 364 feet; the least depth at which water was found was twenty feet. The ordinary depth was between 160 and 225 feet, and the average temperature 76° Fahr. The largest issue of any was 1,267 gallons a minute from that of Sidi Amran, 255 feet deep. In 1878 there were in Algeria 22,360 metres of wells, yielding 22,000 litres of water a second; their total cost was 2,350,000 francs.

The ground of the Sahara is so impregnated with various salts that the water of these wells, pure at first, becomes temporarily brackish. Analyses made by MM. Ville, Vatonne, and De Marigny show that each litre contained one to three grammes of sulphate of soda, one to two grammes sulphate of lime, besides chloride of soda, various salts of magnesium, and carbonate of lime.

A peculiarity of the wells is that tiny little fish, resembling small whitebait, are brought up in the water. They were first noticed by General Zickel in the water spouting from the well of Aïn-Tala, which is 145 feet deep. The length of these little creatures does not exceed one and a quarter inch. Their eyes are well shaped, although they emerge from regions so dark. They are malacopterygians, of the species *Cyprinodon cyanocaster*. Similar specimens have been found in some of the ancient wells of Egypt that were cleared by M. Ayme;

as these, in all probability came from the Nile, and as the sand excavated from those wells is much the same as that of the Algerian borings, it is supposed that in both cases the fish infiltrate through with the water to the subterranean sheets.

It must not be supposed that, once the wells are dug, all labor is at an end. M. Charles Grad, who visited the region in January, 1872, found that several had ceased flowing, and that the greater part had a less issue. A few, on the other hand, he found yielded a greater volume than at first. He studied the matter, as did also M. Ludovic Ville, Directeur des Mines d'Algérie. The causes of the lessening of the flow were found to be the crushing-in of the tubes, the accumulation of sand in them, and the increase in the number of the wells, which caused too great a drain on the reservoirs. The life of the wells there without repairs seems to be twenty-five years; some have been known to last eighty without being cleaned.

The lesson to be drawn from this is expressed by the old saying, "Waste not, want not." Wherever it is possible to dam up the running streams of winter and make a reservoir for the summer, it should be done, and artesian borings made where such streams are not available. Among other places, M. Grad maintained that the fertile basin of the Hodna, situated on the Algerian plateau, would be the scene of that kind of work. These dams have already been extensively built in the province of Oran.

In the Sahara, however, the absence of superficial streams renders artesian borings of paramount importance. They will be limited there not only by the underground supply, but in some places by the hostility of the nomadic tribes who oppose their immediate construction. To what extent they can be relied on to reclaim desert-land is still an open question, but at the very least they can be permanently distributed along the routes of caravans that penetrate into the southern solitude, and with palm-trees planted about them form shady resting-places. Up to 1872 one hundred and fifty thousand palms had been planted in the vicinity of the many wells dug in Algeria; in their shade, after the salty ground had been well washed by the flow of water, vegetables and grain were found to thrive. M. Ville, who has made such a special study of the water of the Sahara, announces that, as a rule, a well will water six times as many palms as it gives out litres per minute.

Not a few minds dwelt many years ago upon the possibility of establishing routes across the desert, but that was generally considered chimerical when account was taken of its dangers, known and unknown, the hostility of the races that inhabit it, the length of the marches under a burning sun, over a burning sand, relying upon occasional wells for water, and liable to utter destruction if caught in the path of one of those terrific storms. Still, having a colony on the north coast of the continent and another on the west coast, it is not to be wondered at that the French, with their indisputable energy, should have thought of uniting them overland. More especially does it seem natural in the early days of steam navigation. Nowadays, when cargoes can be sent from Oran to Saint-Louis (Senegal) in eight to ten days for eight dollars or less a ton, there is no great reason for sending caravans there, whose best time in a straight line would be three months and a half. Among the enthusiasts on that question may be mentioned General Faidherbe, some time Governor of Senegal, who displayed a wonderful amount of energy in the matter. Others were not wanting, including several explorers; the efforts of the latter, however, were rather more in the interests of science than material benefits.

It was about the year 1850 that the attention of the Algerian Government began to be drawn to the project of facilitating communication across the desert. In 1854 the Geographical Society of Paris offered a special reward for any one who should go from one colony to the other *via* Timbuctoo. In 1858 the Algerian Historical Society made a special order of the day a study on the best route and method of reaching Soodan. Finally, in 1873, a company was formed in Algiers, with a capital of thirty thousand francs, and the rather vague name of "Company for the Encouragement of Commercial Explorations in the Sahara." The intention of this company seemed to be to form at Laghouat an entrepot for merchandise suitable to the southern tribes, and to try to draw to Algeria a part of the traffic of Morocco and Tripoli. The Algerian Historical Society had recommended somewhat similar measures in 1860, but they were not carried out—the cause of the failure being attributed to the lack of French agents outside the Algerian frontier. That indefatigible explorer M. Duveyrier, in 1862, proposed a route following the subterranean course of the Igharghar River southward, different from the four routes generally taken by caravans; the Azdjer chiefs, to whose interest it is to encourage traffic across the desert, offered to guarantee the security of the expedition, and the Algerian Government promised to render it practicable by wells. In 1867 an expedition was actually organized, but was abandoned for reasons not generally known.

Since then the project seems to have been dropped, only to be revived again under a different form. The question of a trans-Saharan railroad has been started, which should not astonish us in America who now think nothing of going from New York to San Francisco in less than a week. M. Paul de Soleillet was among the first to propose the construction of a railroad from Algiers to Timbuctoo, and thence to Saint-Louis; in 1872 he attempted to perform that journey to explore the route, but he got no farther than the oasis of Insalah, about six hundred miles south of Algiers, being stopped by the natives. It would seem that a more practicable route would be found farther east, clear of the Tademayt and Ahaggad plateaux, of which the latter attains an elevation of over four thousand feet. The journeys of Barth and Vogel discovered that, at a short distance south of Tripoli, a series of terraces lead gradually to the vast plains of the desert, where there are only moderate undulations with occasional ravines and isolated masses of rock to Soodan. The southern part of the route was over plains slightly inclined southward. The greatest height observed in that region was six hundred metres.

M. Dupouchel, Ingénieur en chef des Ponts et Chaussées, went in 1877 to examine the ground west of the Ahaggad, and study the practicability of opening a railway between Algeria and the valley of the Niger of Soodan. The results of his examinations have appeared in book form, accompanied with maps and drawings. The route that he recommends commences at Algiers, and passes by Afreville, Boghari, Laghouat, and the oases of Touat, finally striking the Niger at Bamba, a short distance east of Timbuctoo. An eastern branch would descend that river to longitude 2° east, and would run from there toward the Tchad Lake. A western branch would ascend the Niger as far as Kouma, and then run to Saint-Louis. The total length of the line from Algiers to the Niger, deducting the part already constructed to Afreville, would be about 1,700 miles, of which the total cost is estimated at 400,000,000 francs (about $77,000,000). This is $15,000 less per mile than the average of all the railroads built in the United States during the year 1874, and $60,000 less per mile than the cost of the Central Pacific. President Grévy has recently been written to, and urged to appoint a commission to examine a proposal to construct that railroad.

It will readily be seen what an important element in the construction of a railway will be the power to supply water from underground as the work progresses. But there are enthusiasts who maintain that the object now to be accomplished is not simply the establishing of communication across the desert, nor the submerging of one very small portion for the benefit of another small portion, but no more nor less than the reclaiming—the fertilization—of the whole Sahara. This, indeed, sounds rash, and yet no less an authority than Gerhard Rohlfs, who has explored greater areas of Sahara than any other European, and whose journey from Tripoli to Rhadames and Fezzan won him a gold medal from the Royal Geographical Society of London, sustains the idea by saying that Nature would soon begin to assist man in the herculean undertaking. According to this traveler, three distinct zones separate the center of the desert from the neighboring lands of the Tchad Lake in the south; in the third or northernmost of these are immense forests of mimosas, where the ground is characterized by the absence of the smallest stone, and which, according to the aborigines, extend from Egypt to Timbuctoo, covering the Kordofan, the Darfoor, the Kamen, and the country of the Touaregs. Professor Rohlfs advances the theory that these forests are encroaching on the desert, and that in time the Sahara will disappear under a vegetation of which the mimosas are the forerunner. "Thus," he adds, "while certain timorous spirits fear that the earth may some day be overpeopled, Nature is silently transforming the soil where man will in the future be able to pitch his tent. The Sahara will be covered with green trees, new lakes will be formed, and the rivers whose dry beds now fill the traveler with horror will be running streams of limpid water as abundant as that of the great streams of Europe."

Such a return to what seems pretty certain to have been the state of things ages ago would be most extraordinary without the help of man. The vast tract comprised between the sixteenth and thirtieth parallels of latitude, and extending from the Atlantic to the valley of the Nile, once fertile, became the arid waste of to-day mainly through neglect. A M. Largeau in 1874 visited the valley of the Igharghar, with the intention of branching off to Rhadames to study the commerce of that oasis and test the practicability of diverting to Algeria the caravans that come there by the central route from Soodan. He questioned the *chambas* on the causes of the drying of the great Saharan streams, and found that all agreed in saying that these dead rivers once ran full through a country more fertile than the Tell (the region north of the Atlas Mountain's crest), but could only explain it by legends more interesting than satisfactory.

M. Largeau gives the following explanation of the change: "It is known that pastoral people have always been great destroyers of forests, for they need large spaces of clear ground to feed the flocks that form their wealth and to promote security against the wild beasts that lurk in forests. Even now the Algerian Arabs are seen firing the woods to enlarge the narrow limits imposed upon them by colonization. So, although the great Saharan streams have not been explored to their sources, yet it is known that they commence on the bare plateaux that are but the skeletons of heights once wooded and fertile. All accounts of the inhabitants of these regions agree on that point. Consequent upon the destruction of the forests the periodical rains were replaced by rare and short though violent storms, the waters from which, instead of soaking in as in past ages, slip by on the rocky masses, carrying away the rich surface mold, and bring about the drying of the springs, and, as a direct consequence, of the rivers."

An admission of this theory leads the way easily and hopefully to the prophecy of Professor Rohlfs, and raises the question whether it would not be better on all accounts to let the salt waters of the Mediterranean circulate in their own proper bed and pursue the more economical work of conquering the desert by assistance from underground. Nearly all the fluvial network of the Algerian Sahara converges toward the Igharghar. Formed by the confluence of several small streams on the slopes of the Ahaggar, it flows northward, and soon sinks through the light sands and pursues its underground course to the western part of the basin that the French contemplate inundating, bearing in that part of its course the name of Oued Rihr, or river Rihr. Into this same depression flows another subterranean stream, the Oued Djeddi, which has its sources on the plateaux of Laghouat in the west. The two streams in all probability united in past ages, and possibly even connected with the Mediterranean. However that may be, there seems little doubt that water in considerable quantities may be found by boring in the dry beds of these two streams. M. Largeau saw several wells in that of the Igharghar, only twenty-five feet deep, giving very sweet water, of a temperature of 70° Fahr.

With this in consideration, and the example of the marabout of Tendouf still in mind, it would seem possible not only to fertilize large areas of Algerian soil, but to bore our way as it were up the slopes of the Ahaggar and gradually restore the rain-causing forests of M. Largeau, which in their turn might attack the desert from the center, as Professor Rohlf's mimosas do from the south.

The lowest estimate of the cost of inundating the depressions in the Algerian Sahara being $5,790,000, we see that that sum otherwise appropriated would pay for boring 7,400 wells averaging 154 feet in depth, assuming the cost per foot to be the same as south of the Ziban oases. Allowing the issue to be only one half that of the wells near Biskra, the total flow would be 1,100,000 gallons per minute, which, according to M. Ville, would suffice for the irrigation of about 24,600,000 palms. One tenth of this labor and expense would produce great results.

So far facts and discussion alike have been limited to the region bordering upon Algeria and Tunis. This is because explorations have naturally been carried on there somewhat to the exclusion of the Tripolitan neighborhood, and not because similar causes and effects may not be found farther east. There is every reason to believe that the desolate region bordering the south shore of the Mediterranean between the tenth and twenty-fifth meridians is destined to experience an equal improvement with the western Sahara. The writer of this article, who was one of a party of officers of the United States Navy engaged in surveying along that coast in 1878, had occasion to observe in several places, notably at Zouaga near Tripoli, and along the shores of the Gulf of Sidra (Syrtis Major), hottest of the hot and driest of the dry, that water was to be had by digging but a short distance. He noticed, also, not a few oases just on the sandy horizon, that bespoke the presence of the life-giving element. An examination of the map shows many more. While this would not be very convincing proof to a skeptical mind, in the absence of organized investigation, it may at least be considered encouraging. The day is not far distant, however, when certain knowledge will confirm or disprove hazardous opinions. The various geographical societies of the world have ceased to let the matter rest, and Professor Rohlfs is even now in charge of an expedition sent out by the German African Society. Last January he was two hundred and fifty miles south of Tripoli, at the foot of the Black Mountains; recent advices show him to be at Benghazi, on the eastern shore of the Gulf of Sidra. Accounts of the expedition have not yet come to hand.

In the event of an increase in the commercial importance of Northern Africa, whether by inland seas, artesian wells, or railroads, or all three, means of transportation to and along the seaboard and thence to foreign ports will not be lacking. As early as 1857 a railway system was decided upon for Algeria, which included a shore-line, with branches inland to various points. The construction of this network is practically completed. On the 1st of January, 1879, there were three hundred and thirty miles of railroad in that colony. A line has also been started to connect Constantine with the city of Tunis, the bondholders being guaranteed six per cent. interest by the French Government. This will probably be completed in a year. In Morocco the development of roads is not great: we can not expect very much anyhow from that sultantate, as present laws forbid the exportation of cereals, for fear of a recurrence of the famine. In the province of Tripoli but little is needed now; when the time comes it will be easy work to build a railroad in so flat a country.

In the matter of ports, Algeria points with pardonable pride to Algiers, Oran, Arzeu, Philippeville, Bona, and several minor harbors that have been made secure by artificial works. The first mentioned was begun in 1530 by Bab Aroudj (*Anglicè* Barbarossa) and his Christian slaves, and finished by Christians guiding the labor of that pirate's descendants. Tunis boasts of a magnificent lake at Bizerta, close to the sea; a little dredging in the short, narrow channel leading out would transform it into an unparalleled harbor for ironclads, of which both Germany and Italy are said to be particularly well aware. In Tunis Bay a single inexpensive breakwater, built in only six fathoms depth, would afford perfect shelter. Farther south and east, Sphax roadstead only wants ships to fill it, and Surkennis only the Bey's order to welcome foreign vessels to which it is now closed. In the province of Tripoli may be mentioned Tripoli Port, Menelaus Bay in the Gulf of Bombah, Marsa Euharit, Marsa Tebruk, all good natural harbors, or needing but insignificant works to render them secure. In Egypt it is unnecessary to mention the splendid port of Alexandria.

The French are the pioneers in the northern part of the African Continent, and it would seem desirable for them to extend their sway to the eastward of Cape Roux. That, however, would cause diplomatic complications: England, Germany, and Italy would surely protest against any projects of annexation. But there is still scope for them in the desert. The nomadic tribes will hardly stop the southward course of empire when French industry and capital fan the breeze of progress.

THE ORIGIN OF THE GYPSIES.

IT has been repeated, until the remark has become accepted as a sort of truism, that the gypsies are a mysterious race, and that nothing is known of their origin. And a few years ago this was true; but within those years so much has been discovered that at present there is really no more mystery attached to the beginning of these nomads than is peculiar to many other peoples. What these discoveries or grounds of belief are we shall proceed to give briefly, our limits not permitting the detailed citation of authorities. First, then, there appears to be every reason for believing with Captain Richard Burton that the Jāts of Northwestern India furnished so large a proportion of the emigrants or exiles who, from the tenth century, went out of India westward, that there is very little risk in assuming it as an hypothesis, at least, that they formed the *Hauptstamm* of the gypsies of Europe. What other elements entered into these, with whom we are all familiar, will be considered presently. These gypsies came from India, where caste is established and callings are hereditary even among outcastes. It is not assuming too much to suppose that, as they evinced a marked aptitude for certain pursuits and an inveterate attachment to certain habits, their ancestors had in these respects resembled them for ages. These pursuits and habits were, that—

They were tinkers, smiths, and farriers.

They dealt in horses, and were naturally familiar with them.

They were without religion.

They were unscrupulous thieves.

Their women were fortune-tellers, especially by chiromancy.

They ate without scruple animals which had died a natural death, being especially fond of the pig, which, when it has thus been "butchered by God," is still regarded even by the most prosperous gypsies in England as a delicacy.

They flayed animals, carried corpses, and showed such aptness for these and similar detested callings that in several European countries they long monopolized them.

They made and sold mats, baskets, and small articles of wood.

They have shown great skill as dancers, musicians, singers, acrobats; and it is a rule almost without exception that there is hardly a traveling company of such performers, or a theatre in Europe or America, in which there is not at least one person with some Romany blood.

Their hair remains black to advanced age, and they retain it longer than do Europeans or ordinary Orientals.

They speak an Aryan tongue, which agrees in the main with that of the Jāts, but which contains words gathered from other Indian sources.

Admitting these as the peculiar pursuits of the race, the next step should be to consider what are the principal nomadic tribes of gypsies in India and Persia, and how far their occupations agree with those of the Romany of Europe. That the Jāts probably supplied the main stock has been admitted. This was a bold race of Northwestern India which at one time had such power as to obtain important victories over the Caliphs. They were broken and dispersed in the eleventh century by Mahmoud, many thousands of them wandering to the West. They were without religion, "of the horse, horsey," and notorious thieves. In this they agree with the European gypsy. But they are not habitual eaters of *mullo bālor*, or "dead pork"; they do not devour everything like dogs. We can not ascertain that the Jāt is specially a musician, a dancer, a mat- and basket-maker, a rope-dancer, a bear-leader, or a peddler. We do not know whether they are peculiar in India among the Indians for keeping their hair unchanged to old age, as do pure-blood English gypsies. All of these things are, however, markedly characteristic of certain different kinds of wanderers or gypsies in India. From this we conclude, hypothetically, that the Jāt warriors were supplemented by other tribes; chief among these may have been the Dom.

The Doms are a race of gypsies found in Central India to the far northern frontier, where a portion of their early ancestry appear as the Domarr, and are supposed to be pre-Aryan. In "The People of India," edited by J. Forbes Watson and J. W. Kaye (India Museum, 1868), we are told that the appearance and modes of life of the Doms indicate a marked difference from those who surround them (in Behar). The Hindoos admit their claim to antiquity. Their designation in the Shastras is *sopuckh*, meaning dog-eater. They are wanderers, they make baskets and mats, and are inveterate drinkers of spirits, spending all their earnings on it. They have almost a monopoly as to burning corpses and handling all dead bodies. They eat all animals which have died a natural death, and are particularly fond of pork of this description. "Notwithstanding profligate habits, many of them attain the age of eighty or ninety; and it is not till sixty or sixty-five that their hair begins to get white." Travelers speak of them as "gypsies." The Domarr are a mountain race, nomads, shepherds, and robbers. A specimen which we have of their language would, with the exception of one word, which is probably an error of the transcriber, be intelligible to any English gypsy, and be called pure Romany. Finally, the ordinary Dom calls himself a Dom, his wife a Domni, and the being a Dom, or the collective gypsydom, Domnipana. *D* in Hindostani is found as *r* in English gypsy speech—e. g., *doi*, a wooden spoon, is known in Europe as *roi*. Now, in common Romany we have, even in London—

Rom	A gypsy.
Romni	A gypsy wife.
Romnipen	Gypsydom.

Of this word *rom* we shall have more to say. It may be observed that there are in the Indian *Dom* certain distinctly marked and degrading features, characteristic of the European gypsy, which are out of keeping with the habits of warriors, and of a daring Aryan race which withstood the Caliphs. Grubbing in filth as if by instinct, handling corpses, making baskets, eating carrion, living for drunkenness, does not agree with anything we can learn of the Jāts. Yet the European gypsies are all this, and at the same time "horsey" like the Jāts. Is it not extremely probable that during the "out-wandering" the Dom communicated his name and habits to his fellow emigrants?

The marked musical talent characteristic of the Slavonian and other European gypsies appears to link them with the Luri of Persia. These are distinctly gypsies; that is to say, they are wanderers, thieves, fortune-tellers, and minstrels. The "Shah-Nameh" of Firdusi tells us that about the year 420 A. D., Shankal, the Maharajah of India, sent to Behram Gour, a ruler of the Sassanian dynasty in Persia, ten thousand minstrels, male and female, called *Luri*. Though lands were allotted to them, with corn and cattle, they became from the beginning irreclaimable vagabonds. Of their descendants, as they now exist, Sir Henry Pottinger says ("Travels in Beloochistan and Scinde," p. 153): "They bear a marked affinity to the gypsies of Europe. They speak a dialect peculiar to themselves, have a king to each troupe, and are notorious for kidnapping and pilfering. Their principal pastimes are drinking, dancing, and music. . . . They are invariably attended by half a dozen bears and monkeys that are broke in to perform all manner of grotesque tricks. In each company there are always two or three members who profess . . . . modes of divining which procure them a ready admission into every society." This account, especially with the mention of trained bears and monkeys, identifies them with the Ricinari, or bear-leading gypsies of Syria (also called Nuri), Turkey, and Roumania. A party of these lately came to England. We have seen these Syrian Ricinari in Egypt. They are unquestionably gypsies, and it is probable that many of them accompanied the early migration of Jāts and Doms.

The Nāts or Nuts are Indian wanderers, who, as Dr. J. Forbes Watson declares, in the "The People of India," "correspond to the European gypsy tribes," and were in their origin probably identical with the Luri. They are musicians, dancers, conjurers, acrobats, fortune-tellers, blacksmiths, robbers, and dwellers in tents. They eat everything, except garlic. There are also in India the Banjari, who are spoken of by travelers as "gypsies." They are traveling merchants or peddlers. Among all of these wanderers there is a current slang of the roads, as in England. This slang extends even into Persia. Each tribe has its own, but the general name for it is *Rom*.

It has never been pointed out, however, that there is in Northern and Central India a distinct tribe, which is regarded even by the Nāts and Doms and Jāts themselves, as peculiarly and distinctly gypsy. We have met in London with a poor Mohammedan Hindoo of Calcutta. This man had in his youth lived with these wanderers, and been, in fact, one of them. He had also, as is comman with intelligent Mohammedans, written his autobiography, embodying in it a vocabulary of the Indian gypsy language. This MS. had unfortunately been burned by his English wife, who informed us that she had done so "because she was tired of seeing a book lying about which she could not understand." With the assistance of an eminent Oriental scholar who is perfectly familiar with both Hindostani and Romany, this man was carefully examined. He declared that these were the real gypsies of India, "like English gypsies here." "People in India called them Trablūs or Syrians, a misapplied word, derived from a town in Syria, which in turn bears the Arabic name for Tripoli. But they were, as he was certain, pure Hindoos and not Syrian gypsies. They had a peculiar language, and called both this tongue and themselves *Rom*. In it bread was called manro." Manro is all over Europe the gypsy word for *bread*. In English Romany it is softened into *māro* or *morro*. Captain Burton has since informed us that *manro* is the Afghan word for bread; but this our ex-gypsy did not know. He merely said that he did not know it in any Indian dialect except that of the Rom, and that Rom was the general slang of the road, derived, as he supposed, from the Trablūs.

These are, then, the very gypsies of gypsies in India. They are thieves, fortune-tellers, and vagrants. But whether they have or had any connection with the migration to the West we can not establish. Their language and their name would seem to indicate it; but then it must be borne in mind that the word Rom, like Dom, is one of wide dissemination, Dūm being a Syrian gypsy word for the race. And the very great majority of even English gypsy words are Hindi, with an admixture of Persian, and not belonging to a slang of any kind—as in India, *churi* is a knife, *nāk* the nose, *balia* hairs, and so on, with others which would be among the first to be furnished with slang equivalents. And yet these very gypsies are *Rom*, and the wife is a *Romni*, and they use words which are not Hindoo in common with European gypsies. It is therefore not improbable that in these Trablūs, so called through popular ignorance, as they are called Tartars in Egypt and Germany, we have a portion at least of the real stock. It is to be desired that some resident in India would investigate the Trablūs.

Next to the word Rom itself, the most interesting in Romany is Zingan, or Tchenkan, which is used in twenty or thirty different forms by the people of every country, except England, to indicate the gypsy. An incredible amount of far-fetched erudition has been wasted in pursuing this philological *ignis-fatuus*. That there are leather-working and saddle-working gypsies in Persia who call themselves Zingan is a fair basis for an origin of the word; but then there are Tchangar gypsies of Jāt affinity in the Punjaub. Wonderful it is that, in this war of words, no philologist has paid any attention to what the gypsies themselves say about it. What they do say is sufficiently interesting, as it is told in the form of a legend which is intrinsically curious and probably ancient. It is given as follows in "The People of Turkey, by a Consul's Daughter and Wife," edited by Mr. Stanley Lane Poole, London, 1878: "Although the gypsies are not persecuted in Turkey, the antipathy and disdain felt for them evinces itself in many ways, and appears to be founded upon a strange legend current in the country. This legend says that, when the gypsy nation were driven out of their country and arrived at Mekran, they constructed a wonderful machine to which a wheel was attached." From the context of this imperfectly told story, it would appear as if the gypsies could not travel farther until this wheel should revolve: "Nobody appeared to be able to turn it, till, in the midst of their vain efforts, some evil spirit presented himself under the disguise of a sage, and informed the chief, whose name was Chen, that the wheel would be made to turn only when he had married his sister Guin. The chief accepted the advice, the wheel turned round, and the name of the tribe after this incident became that of the combined names of the brother and sister, Chenguin, the appellation of all the gypsies of Turkey at the present day." The legend goes on to state that, in consequence of this unnatural marriage, the gypsies were cursed and condemned by a Mohammedan saint to wander for ever on the face of the earth. The real meaning of the myth—for myth it is—is very apparent. Chen is a Romany word, generally pronounced Chone, meaning the moon, while Guin is almost universally rendered *Gan* or *Kan*. *Kan* is given by George Borrow as meaning sun, and we have ourselves heard English gypsies call it *kan*, although *kam* is usually assumed to be right. Chen-kan means, therefore, moon-sun. And it may be remarked in this connection that the Roumanian gypsies have a wild legend stating that the sun was a youth who, having fallen in love with his own sister, was condemned as the sun to wander for ever in pursuit of her turned into the moon. A similar legend exists in Greenland and the Island of Borneo, and it was known to the old Irish. It was very natural that the gypsies, observing that the sun and moon were always apparently wandering, should have identified their own nomadic life with that of these luminaries. It may be objected, by those to whom the term "solar myth" is as a red rag, that this story, to prove anything, must first be proved itself. This will probably not be far to seek. If it can be found among any of the wanderers in India, it may well be accepted, until something better turns up, as the possible origin of the greatly disputed Zingan. It is quite as plausible as Dr. Miklosich's derivation from the Acingani—'Ατσίγανοι—"an unclean, heretical Christian sect, who dwelt in Phrygia and Lycaonia from the seventh till the eleventh century." The mention of Mekran indicates clearly that the moon-sun story came from India before the Romany could have obtained any Greek name. And, if the Romany call themselves Jengan, or Chenkan, or Zin-gan, in the East, it is extremely unlikely that they ever received such a name from the Gorgios in Europe.—*Saturday Review.*

PREHISTORIC RECORDS.

THE caves, tombs, and gravel-drifts of the earth, which are of all objects the most uninteresting to the casual observer, have in our days become strangely eloquent. At the touch of science they have lent a voice to the dumb past. Raising the veil of antiquity, they have unrolled page after page of ancient history, written neither with pen nor pencil, but stamped on the rude implements of war or the chase, imprinted on the few threads of decaying tissue that inwrap the crumbling skeleton, engraved on the bracelet of bronze or silver that encircled the slender wrist of some prehistoric beauty, or chased on the brooch of gold that clasped the mantle of some renowned but forgotten chieftain.

So exact are the deductions to be drawn from these mute records of the past that they have been divided by Sir John Lubbock, in his "Prehistoric Times," into four well-defined ages—the drift age, the age of polished stone, the age of bronze, and the age of iron; each of these marking an advance in knowledge and civilization which amounted to a revolution in the then existing manners and customs of the world. The drift age or Paleolithic period is marked by deposits of rude stone implements; to it succeeds the Neolithic, or age of polished stone, in which the same stone implements were in use, but of a superior class, highly polished and well finished.

The wandering savage who lived by the chase and cut up his prey with the rude, unpolished flint knives of the Paleolithic age was coeval with many extinct animals which then ranged over the wide forests that in those early times covered our own country in common with many portions of the Continent. In the caves of Derbyshire and elsewhere, many of the rudely chipped knives and arrow-heads of these ancient hunters are found, the rudest occupying the lowest strata; showing that even in that remote age man had the same tendency to improve as now, and that the practice of even these rude germs of art led to a gradual perfecting of them. Some of the remains of the ancient Nimrods of that remote and, but for these stone records, unwritten age have been found in caves and sepulchral tumuli; and of all the living races of men they resemble the Esquimaux most closely. With them are found the remains of such extinct animals as the cave-bear, the mammoth, and the woolly rhinoceros; and they appear to have been driven along with these animals toward the north, through the action of some geographical change whose magnitude we have now no means of gauging.

The Neolithic era marked the dawn of a new and higher civilization. In many parts of the country, notably at Hardham in Sussex and in Kent, many collections of polished stone implements have been found, such us stone axes and adzes, chisels, gouges, small saws, hammers, awls for boring, stone picks for turning up the soil, pestles, mortars, querns, and spindle-whorls. Needles have also been found, which imply a knowledge of the art of sewing; and cups and various other vessels of rude earthenware, which show that these old-world folks could ply the potter's craft with a considerable degree of deftness. The bones found show also that they no longer depended for a precarious subsistence altogether upon the spoils of the chase, but that they were herdsmen and fishermen as well. They possessed the horse, a small short-horned ox, two kinds of swine, goats, and horned sheep, with dogs of a large breed. In architecture they were unquestionably far behind, for their dwellings seem to have consisted of pits roofed with wattle. The remains of these ancient Neolithic builders are plentifully scattered over the country. They were all built or rather scooped out upon one plan. There was a circular shaft for an entrance, going down to a depth of from seven to eight feet, five to seven feet wide at the bottom, and narrowing to three at the top; and round this was a chamber or cluster of chambers. In these huts are found a variety of the polished stone implements mentioned above, bones of the domesticated animals, and shreds of pottery. In north Kent there is a series of vertical shafts sunk in the chalk; but these seem to have been rather flint-quarries than the homes of our Neolithic forefathers.

In the north of Scotland, modified perhaps to suit the greater inclemency of the climate, the Neolithic dwellings are somewhat different, and take the form of massive circular huts or burghs, as they are called. In these are found the same stone implements and the same bones of animals. The flint of which these stone implements are made was obtained by quarrying for the flint nodules in the chalk. Many of these mines with the mining tools still remain, with great quantities of chips and splinters; which show that the flint implements were, partially at least, manufactured on the spot where the flint was obtained.

In some instances, caves seem to have been used as dwellings by the Neolithic inhabitants of Europe; and, where not employed as a shelter for the living, they seem to have been frequently selected, when within reach, as a resting-place for the dead. In these cave-mausoleums, numerous skeletons of both sexes and of all ages are found. Where no cave was to be had, the dead, as our readers are already aware, were buried in barrows or cairns; numerous broken implements were laid beside them; and, from the quantities of calcined bones found in some of these graves, it is believed that, in the case of a chief, human sacrifices may have been offered. From the number of these tombs and the plentiful remains of Neolithic dwellings scattered over Britain, we are led to the conclusion that our country, in common with Europe, had in those days a somewhat large and tolerably civilized population, who had flocks and herds, who practiced agriculture, and who were hunters and fishermen.

In the pile or lake dwellings of Switzerland, which are assigned to this era, many interesting discoveries have been made. Three kinds of wheat—one an Egyptian variety—have been found; also two kinds of barley, two kinds of millet, the remains of fruit such as apples and pears, peas, flax, and weeds. For their cattle and swine the lake-dwellers seem to have laid up winter fodder in the shape of acorns and beech-nuts. They made cloth of their flax, and could even weave it into an ornamental pattern. From an examination of the human remains found in these curious lake-dwellings and in the sepulchral caves, the most eminent geologists are of opinion that our Neolithic ancestors were of the same race as the Basque-speaking peoples who are still to be found in the north of Spain and in the south of France.

However acquired, the possession of bronze marks an era of advancement. The dwellings of the people who used it were better, and their circumstances more comfortable, than those of the Neolithic tribes they succeeded. They had axes and sickles of bronze, gouges, chisels, hammers, and knives; and, as a natural consequence, all the products of their labor were superior and better finished. They could weave well a tough and strong fabric, and their clothes were formed of several pieces sewed together. Their cloth is almost invariably of linen—no woolen cloth belonging to this period having been found either in France or Switzerland; but in a wooden coffin discovered in 1861 at Ribe, in Jutland, the remains of a body were found inclosed in a cloak of coarse woolen cloth; a woolen cap covered the head, the lower limbs having been wrapped in woolen leggings. Under the cloak was a woolen shirt, girt round the waist by a long woolen band. A bronze dagger in a wooden sheath had been laid beside the dead hand; and in a small box were a few necessary articles for the long journey toward the spirit-land, consisting of another woolen cap, a comb, and a knife—the whole inclosed in a bull's hide. Another coffin contained the paraphernalia of an ancient belle, a brooch, a knife, a double-pointed awl, and a pair of tweezers—all of bronze, two studs, one of bronze and one of tin, and a javelin head of flint; while a third coffin, that of a baby, contained a small bronze bracelet and a bead of amber. Sir John Lubbock considers that these bodies belonged to the close of the bronze period. Bodies wrapped in woolen cloth have also been found in Britain, as at Seale House barrow near Rylston in

Yorkshire. It is, however, worthy of remark that it is only in the exceptional cases in which the body is turned into adipocere (an unctuous, waxy substance), that woolen cloth is found; in normal circumstances that fabric would disappear far more rapidly than linen.

The bronze remains found in the Rhône Valley prove that the art of metal-working, once acquired, was carried by these early races to great perfection. They were acquainted with the processes of casting, tempering, stamping, and engraving metal. With this discovery of a new art came a simultaneous improvement in the potter's craft; the rude cups of the Neolithic age disappear, and are succeeded by vessels of an endless variety of form and ornamentation, some of which are extremely beautiful. Some of the vases are inlaid with tin, others are marked with the same patterns employed to decorate the Etruscan vases of Italy; while others, found in the pile-dwellings of the Lake of Bourget, have representations of men and animals. The collections of bronze jewelry are also abundant and curious. They consist of bracelets, armlets, long hairpins with decorated heads, rings, ear-rings, girdles adorned with pendants, brooches, buttons, studs and torques for the neck. War being in these early days as common as it appears to be in more modern times, we find well-stored armories, comprising battle-axes, arrows, and clubs, lances and short swords, as also helmets and shields of thin plates of hammered bronze. Their graves resemble those of their Neolithic predecessors, with one important difference—dead bodies were burned as a rule instead of buried, the ashes, inclosed in urns, being placed in the tombs.

In the lake-dwellings of eastern Switzerland the implements found are of bone and stone; but in those of western Switzerland there are rich accumulations of bronze implements and utensils; while in the upper layers of *débris* iron begins to appear; showing how in its turn the bronze was supplanted by a metal still more universally useful, and destined to be the type of a grand era of enlightenment and progress. Almost as interesting and instructive as the lake-dwellings of Switzerland are the Danish kitchen-middens or shell-mounds, refuse-heaps which have accumulated round the tents or huts of the primitive population. Many of these have been examined; and rude flasks, sling-stones, axes, flint fragments, and the bones of various animals, have been obtained from them.

In primeval times, many animals were abundant in our own country and all over Europe, which seem gradually to have disappeared. Some of these enumerated by Sir John Lubbock are the cave-bear, the cave-hyena, the cave-lion, the mammoth, the woolly-haired rhinoceros, the hippopotamus, the musk-ox, the Irish elk, the wild-horse, the glutton, the reindeer, the auroch, and the urus or wild-ox. Simultaneously with these or with some of these were human beings, who harbored in caves, and whose skeletons are found in caverns mixed up with the bones of these animals, and with stone or bronze implements.

About these cave-men there is necessarily much less information than there is about those of the Neolithic period ; comparatively few skulls have been found which were in a state that admitted of restoration ; and, among these few, there are great differences.

With regard to the antiquity of man, Sir John Lubbock, after carefully examining the views of many eminent geologists, comes to the conclusion that man certainly existed in Western Europe during the period of the mammoth and the *Rhinoceros tichorhinus*, and that the presumption is that he also existed in Pliocene and even in Miocene times ; but the proofs of that—the remains of the earliest representatives of our race—are to be sought, he thinks, in warm, almost in tropical climates.

From the manners and customs of modern savages much light may be thrown upon the early condition of prehistoric man. After considering the condition and progress of the Hottentots, Veddahs, Australians, South-Sea Islanders, Esquimaux, and others, Sir John Lubbock remarks that, in reading any account of the savage races at present existing in the world, "it is impossible not to admire the skill with which they use their weapons and implements, their ingenuity in hunting and fishing, and their close and accurate powers of observation." By all these qualities we may suppose prehistoric man to have been distinguished in at least an equal degree. The habits and customs of existing savages, however, while presenting many points in common with each other, present also many points of divergence, arising from independent development ; and such was no doubt also the case in the most ancient times : the degrees of civilization even in the stone age would differ much.

It is evident that man when he first spread over the surface of the earth must have been in a condition represented by the lowest type of savage. Then by slow degrees, by imitation, and by the teaching of experience, the capacity of lodging and clothing himself, and of improving his simple implements, would develop and expand, until man, physically one of the weakest and most unprotected of all animals, would, to quote from our author, "by dint of that subtile force which we term mind," make himself independent of nature, careless of the inclemency of the seasons, skillful to force from the stubborn soil the food which suited him, or the ores from which to forge the weapons which gave him power ; till at last, "monarch of all he surveyed," he could cope in his native coverts with the shaggy lion, and be more than a match for the fierce wild-bull, and overtake in the chase the fleet stag or bounding antelope.

The wild man, like the wild beast, is always timid, always suspicious, always on the watch ; and the condition of the savage woman is still more cruel. "She shares," says Sir John Lubbock, "all the sufferings of her mate, and has also to bear his ill-humor and ill-usage. Even the possession of beauty, far from being an alleviation, is only an aggravation of the evils of her lot, by securing for her a hard thralldom to many masters."

With growing civilization, on the other hand, come security and confidence, and that sense of justice and honor which is the best protection of the weak; and, with the increasing and ameliorating influences of science, a great improvement may still be looked for in the condition of our race. We stand perchance upon the threshold of a future, brighter than even the brightest dreams of our past; on the verge of a Utopia long deemed impossible, when the moral nature, unvitiated by an erring will, shall no longer fetter the eager soul to base aims and unworthy aspirations, but shall leave it to its free scope and native regality of birthright and action. Then to the human race, still in its vast masses so ineffably degraded, a new and more mighty civilization may unlock boundless stores of knowledge and power, and unseal fresh fountains of pure and unfailing enjoyment.—*Chambers's Journal.*

SKETCH OF BENJAMIN SILLIMAN.*

THERE is no other name so long and closely associated with the history of American science as that of Silliman. The first who made it illustrious was Benjamin Silliman, born in 1779, and educated for a lawyer, but who entered the field of science early in the century, accepting the new chair of Chemistry in Yale College in 1802. He was a pioneer in the department of geology, contributing to the formation of that science, not only by observations and explorations, but ably maintaining its claims and rights when these were strenuously resisted by an unenlightened public opinion. Professor Silliman also rendered an incomparable service to American science by founding, in 1818, the "American Journal of Science and Arts," but better known, both in Europe and America, as "Silliman's Journal." Of this periodical, he was for twenty years sole, and for eight years more the senior editor. After half a century of duty in the college he resigned his professorship, and died in 1864.

BENJAMIN SILLIMAN, Jr., son of the preceding, and the subject of the following notice, was born in New Haven, December 4, 1816, and entered college in August, 1833. After graduation he was employed as assistant and teacher in the departments of Chemistry, Mineralogy, and Geology in Yale College, and in original studies and investigations in these sciences and their practical applications in the arts. He became associate editor with his father, in 1838, of the "American

* For this sketch we are indebted to the "Yale Book," published by Henry Holt & Co.

Journal of Science and Arts," until the close of the first series of fifty volumes of that journal in 1845. In 1846, with the accession of Professor James D. Dana, the management of the second series of that journal devolved upon the younger editors. In the same year he was appointed at Yale Professor of Chemistry applied to the Arts, the first appointment in the "Fourth Department of Philosophy and the Arts," then inaugurated, and which is more particularly mentioned below. His "First Principles of Chemistry" appeared in this year, of which over fifty thousand copies have been sold. He was a member of the Common Council of the city of New Haven in 1845–'49. In 1845–'46 he gave in New Orleans a course of lectures on agricultural chemistry, upon the invitation of the leading professional and commercial men of that city, and this, it is believed, was the first course of lectures on that subject given in the United States.

In 1849 he was elected to the chair of Medical Chemistry and Toxicology in the Medical Department of Louisville University, at that time in a highly prosperous condition, the duties of which he discharged for five winters. In 1854 he resigned this chair, to take up the instruction in chemistry in the Academical and Medical Departments at Yale, made vacant by the resignation of his father, the Geology and Mineralogy having been assigned to Professor Dana. This instruction was given under the appointment to the chair of "General and Applied Chemistry" (1854). He resigned his duties in the Academical Department in 1870.

In 1858 he published "First Principles of Natural Philosophy or Physics," and a second edition of the same in 1861.

Mr. Silliman visited Europe with his father in 1851, and subsequently edited his father's "Visit to Europe in 1851," 2 vols.; the work having been originally prepared for three volumes, it was cut down to two volumes, to match the author's "Visit to England, Holland, and Scotland, 1805."

He visited California in March, 1864, returning in February, 1865, and again in 1867 and 1872, being occupied with professional work in the mines and in mineralogical and geological explorations. He delivered the annual oration before the College of California in 1867, which has been published.

Mr. Silliman has for some years been much occupied as a scientific witness in the courts, having been employed in many important causes in which scientific testimony and investigation were called for. His aid has been also constantly invoked in various matters connected with the practical arts, where a knowledge of scientific principles is involved.

In addition to the works named above, he has printed many memoirs upon various scientific and practical subjects, addresses and opinions too numerous to mention, besides his original investigations recorded in the "American Journal of Science and Arts."

He was one of the fifty original members named in the act of Congress in 1863 incorporating the National Academy of Sciences, and served the Government in this capacity during the war upon some important commissions.

He is also one of the trustees of the Peabody Museum of Natural History, provided by the munificence of the late George Peabody, of London; and is a member of numerous scientific societies on both sides of the Atlantic.

In 1849 he received the honorary degree of M. D. from the University of Charleston, South Carolina.

In 1853 Mr. Silliman had charge of the chemical, mineralogical, and geological department of the Crystal Palace in New York; and also, in connection with Mr. Charles R. Goodrich, edited the "World of Science, Art, and Industry," illustrated, 500 figures, pp. 207, 4to; and in 1854, "The Progress of Science and Mechanism," 4to, pp. 258, in which the chief results of the great Exhibition were recorded.

In 1868 Professor Silliman parted with his private cabinet of minerals, of his own collecting, to Cornell University, where it is now exhibited as the "Silliman Cabinet." He has made important additions to the mineralogical collections of Yale College, and to the metallurgical cabinet of the Scientific School, the results of his various explorations. He solicited the funds by which the mineralogical cabinet of the late Baron de Lederer was added to the college collections in 1843.

In 1842 Mr. Silliman commenced to receive private pupils in analytical chemistry and mineralogy, in an apartment of the old laboratory in Yale College, which he had fitted up at his own expense for this purpose and to conduct original investigations in science. Previously to this time there had been no provision made for the instruction of advanced students in physical and chemical science either at Yale College or elsewhere in the United States, and the academical students had been instructed in chemistry almost exclusively by public lectures. From the first it was evident that there was the germ of a new development in the small beginning, which soon took form as the "Yale Scientific School," and subsequently grew into the "Sheffield Scientific School."

Among the first students who sought Professor Silliman's instruction were Mr. John P. Norton and Mr. T. Sterry Hunt, since among the most distinguished men of science in the United States. These studies were entirely outside the college curriculum. The college for some years took no cognizance of this effort, which was sustained solely as an individual enterprise. The students it brought to the university were not even recognized as such, and their names did not appear for some years in the college catalogue. But in 1846 a memoir was addressed to the corporation of Yale College, drawn up chiefly by Mr. Silliman, Jr., but adopted and ably seconded by his father, who personally advocated it before the corporation at their session in July, 1846. This memoir contemplated the official recognition and organization of the new department of advanced science-teaching which had, unbidden by and almost unknown to them, sprung into existence. The result was the appointment of a committee and the widening of the plan to embrace advanced instruction in other subjects, at the suggestion of Mr. Woolsey. This committee reported in 1847 the plan of a "Fourth Department," devoted to philosophy and the arts, the first appointments to which had already been made in 1846—Mr. John P. Norton to agricultural chemistry and Mr. Silliman to chemistry applied to the arts. The "Yale Scientific School" as then organized commenced its operations in 1847, opening its laboratories in the old Presidential Mansion (formerly the dwelling of Dr. Day and Dr. Dwight).

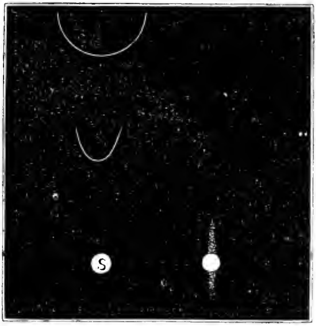
It is proper to record the fact—as showing under what difficulties and discouragements these early efforts were made—that beyond an income of three hundred dollars per annum paid for a few years by a liberal friend of the college, at the solicitation of Professor Silliman, the new department was absolutely penniless, and the entire cost of fitting and furnishing the laboratories, apparatus, libraries, and cabinets, was paid out of the private means of the two professors; who also for two years (to the shame of the corporation be it said) paid into the college treasury *a rental* for the use of the old house they had also paid for adapting and fitting for these purposes! Little encouraging as were these small beginnings, there were not wanting the zeal and enthusiasm which were better than gold, and which were reproduced in the early pupils. From its very commencement this new undertaking bore good fruit. Pupils came up in goodly numbers, and the first classes embraced names now widely known on both sides of the Atlantic. Of these, three—Brewer, Brush, and Johnson—are now professors in the Sheffield Scientific School. Out of the effort which he then commenced single-handed, and to which he devoted some of the best years of his life—always paying his own salary—has grown up a new college, embracing more professors than the old academic college had when he graduated in 1837, with two hundred students, and with constantly increasing power and endowments.

CORRESPONDENCE.

INTERESTING LUMINOUS PHENOMENON.

Messrs. Editors.

A BEAUTIFUL and unusual phenomenon was observed here on the afternoon of the 13th instant. Between three and four o'clock, the western sky being partially covered with cirri, and obscured near the horizon by a dense haze, about thirty degrees horizontally north of the sun was seen a mock-sun of dazzling brilliancy. Extending from it above and below was a luminous haze, of too small an extent and too indefinite outline at its extremities to exhibit any curvature. The entire mass of light thus appeared to have an oblate form, very much elongated vertically, the brilliant mock-sun forming its nucleus. On its sunward side the colors of the solar spectrum were plainly visible. In the clear sky, directly over the true sun, and about half-way to the zenith, was an inverted arch of pale white light, of parabolic form, with its axis to the sun, its extremities, which faded off into the blue, being five or six degrees apart. Directly overhead was an arc of a circle, of



still fainter light, whose apparent radius was about ten degrees. No prismatic tints could be detected in either of these arcs. The situation of the objects described is roughly shown in the diagram. The sky to the south of the sun was so covered by cirro-strati as to obscure any parhelion that might otherwise have been visible there. A noticeable feature of the phenomenon was the distinctly *parabolic form* of the middle arc of light. Never having seen this particular feature described in accounts of similar phenomena, I would ask if it is a usual accompaniment of them, and at the same time would ask if any satisfactory explanation of the cause of parhelia and the accompanying circles, other than the partial explanations of Huygens and Fraunhofer, has yet been given?

On the morning following the appearance described, we had light flurries of snow, and afterward rain.

G. B. SEELY.

BOSTON, *December* 15, 1879.

"THE AGE OF ICE."

Messrs. Editors.

I HAVE been placed in a false position through your publication, without date, of my article bearing the above title in your October issue of the current year. I am accused, by a paper called the "St. Louis Globe-Democrat," of plagiarizing from Croll and Merriman. Permit me to state that the article was written in 1874, nearly six years ago, and read at the session for that year of the Kansas Academy of Science, as the archives of that body will testify. I think Croll's book was not at that time published. Geikie's, if published, had not yet reached us in Kansas; and Mr. Merriman did not write till a later period. I had seen nothing on the subject but St. Pierre's "Studies of Nature," and a fugitive fragment from Adhemar. I think my manuscript was handed in too late to be printed in the "Transactions" of the Academy for that year; but doubtless the record of its presentation in 1874 is on file. I left Kansas soon after, and had seen nothing of my article from that time till the day it appeared in the "Monthly." You will testify that it was published without my knowledge.

I should have sooner adverted to the matter, only that I hoped the article would remain in the oblivion to which its slender merits entitled it; but now that I am charged with plagiarizing from men who, though vastly superior in knowledge and research, really wrote after I did, I beg space for the above, or for some editorial statement of a corresponding character.

I am yours, very respectfully,

H. B. NORTON.

SAN JOSÉ, CALIFORNIA, *December* 22, 1879.

Mr. Norton's article, referred to above, was received by us November 2, 1874, and was never afterward in the hands of the author, nor did he know when it was to appear. The work of Mr. Croll on "Climate and Time" was published in London about six months later, or in the spring of 1875; and Mr. Merriman's articles, from which Mr. Norton is accused of borrowing, first appeared in "The Popular Science Monthly" for April and June, 1876, nearly a year and a half after the receipt of Mr. Norton's paper.—EDITORS.

EDITOR'S TABLE.

VENGEANCE IN PUNISHMENT.

THOSE dainty purists who "do not like the word *Sociology*," and are therefore hindered from taking interest in the science that passes under the name, may get a glimpse of one of its problems in unobjectionable form by reading the able paper of a practical lawyer which opens the present "Monthly." Of all the questions by which modern society is agitated, there is none more momentous than that of the public treatment of crime and criminals. No man can be found so stupid as to maintain that the present practice is satisfactory; and but few have the wisdom to indicate anything that is really much better. In this state of affairs the first thing required is to understand how present conditions were reached; and what is the nature of those changes that have brought past amelioration, and may lead on to a still better state. Only when the laws of social progress are discovered and made widely known can they be conformed to by communities with solid and lasting advantage.

We have a system of penal laws for the protection of individual rights and the conservation of society by punishing prescribed offenses; and the general notion is, that this system is coeval with government, and was originally instituted essentially in its present form and for its present purpose. This, however, is a great mistake, as is instructively shown by Mr. Billson. He points out that the first rude governments have only a concern for themselves. Government arose in tribal antagonisms, was a militant organization against external foes, and recognized no crimes except such as treason, cowardice, desertion, or such acts as injured itself. There was, at first, not the slightest idea of protecting citizens against crime by punishing private offenses. Individuals were left to redress their own grievances. Murder, for example, was a private wrong, to be privately avenged by a relative of the victim, who was at liberty to kill the murderer. Government had no internal police or judicial processes, and the rule of punishment was that of private personal vengeance. Society, as a consequence, was torn by internal feuds and bloody violence, and was ruled by the spirit of retaliation and revenge. Mr. Billson shows us the extent and atrocity and tenacity of this system, and how criminal law arose out of the necessity of regulating the excesses of malignant blood-avengement.

This chapter in the criminal history of society has a grave significance as interpreting the spirit by which crime is still treated. For, although civilized society has made great advances in framing penal codes on principles of justice, and although government has abolished private retaliation, and itself assumes the prerogative of punishing crime, it has not outgrown the vindictive passions of the barbarous past. The practice of dueling, a vestige of the old private avengement of wrong, is not extinct; and in the prison-treatment and public execution of criminals we still see survivals of the old savage feeling of vengeance that has not yet died out of the community. By the abolition of torture we have conceded that criminals have rights, but no conception of the correlative rights of the criminal and of society is allowed to determine the kind and degree of punishment. A criminal is one upon whom vengeance is to be wreaked, and this feeling barbarizes the prison overseer, and brutalizes the convict so as to make his existence a curse to himself, and if set free he is more inveterately at feud with society than he was before "justice" took him in hand. What but the spirit of vengeance is it in society which prevents the convict from having all the sympathy of treatment and chance of self-help and amendment that are consistent with his detention in prison as a measure of public security? The surviving spirit of revenge is again seen in the tenacity with which society clings to its brutal modes of execution, turning them into shows for a select company, so that the details may be scattered through the land, and all may enjoy the ghastly accompaniments with which vengeance has been satisfied. In the course of social progress the vengeful feelings have been more and more constrained by the growth of humane sentiments, and their modes of exercise have been transformed, but there is plenty of room for further salutary change.

SCIENTIFIC TEACHING IN THE COLLEGES.

The gradual acceptance of the doctrine of evolution among our theological friends is causing some perturbation which it is important to notice. Our orthodox contemporary, the "Independent," recognizing the mischief that is being done by the obstinate refusal of religious teachers to accept the conclusions of science, came out strongly in favor of the evolution theory. Dr. McCosh had declared, in addressing the Evangelical Alliance in New York: "It is useless to tell the younger naturalists that there is no truth in the doctrine of development, for they know that there is truth which is not to be set aside by denunciation. Religious philosophers might be more profitably employed in showing them the religious aspects of the doctrine of development; and some would be grateful to any who would help them to keep their old faith in God and the Bible with their new faith in science." The "Independent" took this ground, and in its article upon the subject said: "We are all taught in our best schools, by our scientific authorities, almost without exception (and we laymen in science are, therefore, compelled to believe), that man was, at least so far as his physical structure is concerned, evolved from irrational animals. We, therefore, can not help doubting, as every thinking and scholarly young man [in these schools] must and does doubt, whether the story of the fall in the first Adam is historical."

The cautious and vigilant "New York Observer" now took the alarm. It sent this passage to nine presidents of colleges, and asked them if it was true that it represented the teaching in their respective institutions. Dr. Porter, of Yale, replied, "The inclosed does not give a correct representation of the teaching in this college by our scientific authorities." Dr. McCosh, of Princeton, said: "In answer to your inquiries I have to state that we do not teach in this college that man is 'evolved from irrational animals.' I teach that man's soul was made in the image of God, and his body out of the dust of the ground. I do not oppose development, but an atheistic development." Dr. Chadbourne, of Williams, answered: "The doctrine is *not* taught here that man, even in his *physical nature*, was evolved from one of the lower animals. Wallace, who claims with Darwin the honor of the doctrine known as 'Darwinism,' admits that its principles *fail* when applied to man." President Cattell, of Lafayette, replied: I have never heard of any of my colleagues expressing, either in private or in the class-room, the opinion referred to in the slip you send me. We are keenly alive here to the danger from what is manifestly the infidel *trend* of the views generally held by evolutionists. It is a great relief to me to know that among all my colleagues there is such a cordial acceptance of the old faith, which it has been the tendency or the avowed aim of these materialistic teachers to destroy." Dr. Brown, of Hamilton, responded: "The doctrine of the 'evolution of man from irrational animals' has never, to my knowledge, been taught in Hamilton College. I trust it never will be till it is proved to be true, as in my judgment it has not been, and I do not think it ever will be." President Potter, of Union, declared, "The printed statement you forward is *not* a correct statement of the teaching in this college." President Robinson, of Brown University, replied, "We do not teach the doctrine stated in the inclosed slip." Dr. Anderson, of Rochester University, protested that "we have never taught in our institution that man is 'evolved from irrational animals,' for the simple reason that we believe the notion to be an unverified hypothesis." And President Seelye, of Amherst, indignantly responded: "This college does not yet teach groundless guesses for ascertained truths of science. So long as the notion that man is evolved from the monkey or from any irrational animal has not a single fact to rest upon, and is in flat contradiction to all the facts of history, I think we may leave it with the sciolists."

Now, this unanimity of unqualified denial has its significant implications. For, if evolution is not taught in those colleges, we may fairly infer that it is because the old alternative doctrine has not been given up; that is, as President Cattell observes, there is among his colleagues "such a cordial acceptance of the old faith." Hence we learn that, on a large question of natural history, nine of the leading American colleges teach the old theological beliefs rather than the conclusions of modern science.

The "Observer" of course exultingly avails itself of the official declarations it has elicited, and points the moral of the case by restating the biological teaching of "the Holy Scriptures," still inculcated in the colleges. It triumphantly asks of the "Independent": "Where are the schools, 'our best schools,' in which its vile doctrine is taught? Degrading as the doctrine is, opposed to the common sense of mankind, contradicted by science and history and the Holy Scriptures, what reckless audacity there is in asserting that it is taught in our best schools!" Again it says: "The Apostle Paul affirms that 'by man came death,' and that 'in Adam all died,' and that 'death reigned from Adam to Moses,' and that 'by one man's offense death reigned by one.' But the 'Independent' says that 'every scholarly young man' must doubt whether the fall in Adam is a fact. The historian Luke traces the lineage of the Son of Mary from son to father, step by step, till he gets back to Seth, 'who was of Adam, who was of God.' This is the Biblical history of development, by which the human race is traced to the time when Moses says God made man and called him Adam. . . . No young person whose mind receives the views of the 'Independent' can at the same time be a believer in the oracles of divine truth. To hold the one is to despise the other. If the irrational animal gospel is true, Christ's gospel is a humbug."

Such is the theological biology to which the presidents of nine American colleges are thus authoritatively construed as committing themselves and their institutions.

Several interesting questions here arise, and the first is an unpleasant inquiry as to how far these presidential declarations are fair and true. Do they represent the facts or do they mislead?

We leave this question to be answered by the "Independent." Having gone behind the returns and looked into the subject, it reports that, in Yale, Professors Marsh and Dana are pronounced evolutionists, and that what is true of these two men is true of Verrill, Brewer, Smith, and of all the other teachers of the biological sciences in Yale College; and it quotes Marsh as having said before the American Scientific Association: "It is now regarded among the active workers in science as a waste of time to discuss the truth of evolution. The battle on this point has been fought and won." As regards Princeton, the "Independent" says: "Dr. McCosh is quite outspoken in defense of the legitimacy of evolution, though not a Darwinian nor a naturalist. Professor Macloskie, their only naturalist, a man who has developed remarkably within a few years, is even more decided in the same direction, as are, without reserve, the distinguished Professors of Astronomy and Physics, Young and Brackett."

In respect to Brown University, we are told that "Professor A. S. Packard, Jr., is the only instructor in zoölogy or botany that we recall in Brown. He fully believes in evolution—man's physical structure no exception—and his published books support evolution through and through."

As to Amherst, "It is sufficient to state that the Professor of Geology in Amherst is an unreserved theistic evolutionist, who teaches the antiquity of the human race, and we have no doubt the same is true of his young colleague in natural history."

The "Independent" then presses the question as follows:

"Why did not the 'Observer' inquire of the President of Harvard College? Probably because he was afraid of the answer he would get. But did he not know that Harvard is one of those 'best schools,' having 'scientific authorities,' which we were talking about; and that Louis Agassiz, the great opponent of evolution, the most influential naturalist that ever lived in America, was a Harvard professor, while Asa Gray, the great American botanist, a champion of religion against materialism, and a devout member of an orthodox church, is another Harvard professor? But its omission was wise. Of all the younger brood of working naturalists whom Agassiz educated, every one—Morse, Shaler, Verrill, Niles, Hyatt, Scudder, Putnam, even his own son—has accepted evolution. Every one of the Harvard professors whose departments have to do with biology—Gray, Whitney, A. Agassiz, Hagen, Goodale, Shaler, James, Farlow, and Faxon—is an evolutionist, and man's physical structure they regard as no real exception to the law. They are all theists, we believe; all conservative men. They do not all believe that Darwinism—that is, natural selection—is a sufficient theory of evolution; they may incline to Wallace's view, but they accept evolution. It is not much taught; it is rather taken for granted. At Johns Hopkins University, which aims to be the most advanced in the country, nothing but evolution is held or taught. In the excellent University of Pennsylvania all the biological professors are evolutionists—Professors Leidy and Allen in comparative anatomy, Professor Rothrock in botany, and Professor Lesley in geology. We might mention Michigan University, Cornell, Dartmouth, Bowdoin; but what is the use of going further? It would only be the same story. There can scarcely an exception be found. Wherever there is a working naturalist, he is sure to be an evolutionist. We made inquiry of two ex-Presidents of the American Association for the Advancement of Science. One wrote us, in reply, 'My impression is that there is no biologist of repute nowadays who does not accept, in some form or other, the doctrine of derivation in time, whatever be the precise form in which they suppose the evolution to have occurred.' His successor replied: 'Almost without exception, the working naturalists in this country believe in evolution. . . . In England and Germany the belief in evolution is almost universal among the active workers in biology. In France the belief is less general, but is rapidly gaining ground. . . . I should regard a teacher of science who denied the truth of evolution as being as incompetent as one who doubted the Copernican theory.' We challenge the 'Observer to find three working naturalists of repute in the United States--or two (it can find one in Canada)—that is not an evolutionist. And where a man believes in evolution, it goes without saying that the law holds as to man's physical structure."

These, then, are the "sciolists," the smatterers, the shallow novices, to whom President Seelye leaves the subject; meantime the learned professors of Amherst illustrate the dignity of scholarship and the ripeness of knowledge by teaching the biology of the ancient Hebrews. The theory of evolution is now guiding the researches of the scientific world because it is being constantly and increasingly verified in the new results to which it leads; but President Anderson will not teach it because it is "an unverified hypothesis." Has he a verified hypothesis, then? or do they, at the University of Rochester, dodge the foremost philosophic question of the age?

The college presidents seem to resent the imputation that they teach the derivation of man from "irrational animals"; and the "Observer" calls the doctrine "vile" and "degrading." There is a current vulgar belief that the idea of human derivation from inferior animals is scandalous and revolting. But is not this, after all, the established method of producing man? What is a new-born babe but an "irrational animal," and does not each president of a college come from such an "irrational animal" by a process of development? And that is not all. Each human individual, beginning as a protoplasmic germ, is evolved step by step, passing in the gestative period through type after type of "irrational animals" before the developed human life begins. Will the nine doctors of divinity be good enough to say who it was that they think designed this arrangement? And do they not, moreover, teach that the Creator first tried the miraculous method of bringing people into existence at once and perfect, and then abandoned it for the present plan of developing them gradually out of "irrational animals" through the common processes by which inferior creatures are multiplied?

EDUCATION FOR GUIDANCE.

We heard a good thing recently of a distinguished Professor at a distinguished university, eminent for its high-toned devotion to the interests of pure scholarship. The Professor had been lecturing upon a favorite subject, and declared the charm of it to be that "it could not possibly be prostituted to any practical or useful purpose." There is much to admire in this plucky spirit of devotion to truth for its own sake; but it is easy to make this transcendent state of mind subservient to a very bad utility. And, while we value great seats of learning, which provide for the devotees who pursue knowledge for the love of it, we have to guard against the prostitution of this idea to pernicious ends in current education. For, while the exceptional scholar may ignore the practical and the beneficial, the mass of mankind can not do so. They live in a world of action and struggle, and have minds to guide them in their labors and conflicts. These minds require cultivation, that they may do their work better. Knowledge is, therefore, for guidance, and education for the more intelligent direction of the activities and work of life. But this principle is far from being yet recognized in current education. The lower schools seize upon the higher ethics of university study and pervert them into a defense of their own bad practices. They teach worthless things, on the pretense that the kind of knowledge is of but little account, as education is only concerned with mental training. The crudeness and inefficiency of teaching are excused upon the plea that mental discipline is the thing aimed at in study. Our whole school system is imbued with this vicious fallacy, which is the great obstacle to rationalizing school methods. The knowledge that is of most worth is either not taught or is taught so loosely and carelessly that it is of but little practical use; and the consequence is, that our boys are turned out into the world so ignorant and incompetent that they are defenseless in the exposures of every-day experience.

What shall we say of a system of education which throws its students into society unable to protect themselves from the grossest impostures? To what end is a community filled with colleges, high-schools, and common schools, upon which millions of dollars are spent, when its graduates go out to become the ready prey of charlatans and sharpers, who can enrich themselves by pushing the most absurd and preposterous projects?

We are led to these reflections by the last curious report of lightning-rod swindles. The proud State that gives us our President and Chief Justice, and makes a great ado about its education, has also the honor of originating and harboring "Chambers's National Lightning Protection Company" of Cincinnati. The Americans are a progressive people, great on improvements, and the Westerners are specially wide-awake in this respect. So the new lightning-rod is a great step forward in inventive science. It is laid flat upon the ridge of the building, and turned up at the two ends, and has no connection with the ground. Its *rationale* seems to be that the lightning-discharge is caught upon one of the points, and, there being no rod to convey it to the earth, it is obliged to "diffuse back into the air where it belongs and whence it came." Of course, such an arrangement is worthless for protection, and is, moreover, absolutely dangerous, as every intelligent schoolboy ought to know; and yet such is the grossness of public stupidity that the company drove a thriving business with their contrivance, mounting it upon a great number of private dwellings, and even upon school-buildings. Professor Macomber, of the Agricultural College at Ames, Iowa, seeing the extent to which people were humbugged by this so-called "Protector," publicly denounced it as a fraud, whereupon he was prosecuted by the company, which laid its damages at $50,000. As the thing was getting serious, the Professor concluded to make thorough work with the exposure, and accordingly appealed to a large number of scientific men of the highest reputation, to give their opinion of the "Chambers rod." He has published the replies of Morton, Anthony, Rood, Mayer, Clarke, Baird, Newcomb, Todd, Le Conte, Silliman, Kedzie, Davies, Edison, Trowbridge, Rowland, Young, Hinrichs, Harvey, Pickering, Loomis, and Tyndall, who all agree that it is a worthless humbug, of no use for protection, and an actual danger to any house upon which it is placed. Yet the company will probably suffer but little interruption in its business, as its main stock in trade is public ignorance and credulity. The lightning-rod fiend may be expected to ply his profitable vocation until the common schools do better work than they have accomplished hitherto.

The abridgment of Judge Daly's recent address before the Geographical Society, on the early history of cartographical art, may be commended to the attention of our readers, but we must remind them that it is a very incomplete representation of the original lecture. A condensation in literature is generally the worst kind of mutilation; for, instead of cutting the thing into large sections by which considerable portions are left unmutilated, the condenser performs his crushing operation on the whole, so that very little is left as the author puts it. Compression is often necessary, but it is generally at the expense of the symmetry and finish of the performance. The President of the Geographical Society expresses regret that his pressure of legal duties during the past year had not allowed him time to work up the progress of current geographical discovery, as he has been in the habit of doing in the preparation of his annual address. But in place of it he has given the world unquestionably the best monograph on the history of map-making in connection with the development of early geography that can anywhere be found. It is a careful statement, laying under contribution all the resources of geographical erudition, and the few small cuts we reproduce from it but poorly represent the full series of old maps that have been prepared to illustrate the subject, and are contained in the pamphlet issued by the Geographical Society. To that document the reader is referred for the ampler and more satisfactory discussion of the subject.

LITERARY NOTICES.

Octavius Perinchief: His Life of Trial and Supreme Faith. By Charles Lanman. Washington: James Anglim. Pp. 403. Price, $2.

This is the biography of a devout clergyman, who was at the same time a cordial and fearless friend of science. We call attention to some features of the work that illustrate this combination of traits.

The subject of it was born in Bermuda in 1829. He got the rudiments of a common education there, and came to New York at the age of eighteen. Having a thirst for study, and deciding to become a clergyman, he went to Amenia Seminary, and then to Trinity College at Hartford. After graduating there he taught a year at Racine College, Wisconsin, and then wound up his professional studies in the General Theological Seminary in New York. He was ordained by Bishop Potter as a clergyman of the Episcopal Church in 1857.

Mr. Perinchief's pastoral experiences were varied. He had charge of several parishes, beginning to preach in Brooklyn; he afterward went to Bridgeport, then to York, Pennsylvania, from which he removed to Mount Holly, New Jersey, and finally returned to Bridgeport, where he died in 1877, at the age of forty-seven years.

Mr. Perinchief was during all his adult life an invalid and a great sufferer. Straitened in means, and fighting his way through the educational institutions, he was often subjected to great privations, living for long periods on bread and water, with insufficient clothing, which, with the customary overwork in such circumstances, permanently impaired his constitution. Besides this, he early met with a terrible accident which produced a lesion of the spine, that was ever afterward a source of much pain and prostration.

It is hardly possible that so intense and prolonged an experience of physical suffering could have been without its influence upon his mental life. Yet he was far from being the victim of his bad bodily conditions. His subjective experiences did not color or distort his view of the world. His manhood triumphed over the unhappy accidents of his lot, and the influence he exerted upon all around him was in a remarkable degree healthful, ennobling, and purifying. He had a large measure of that quality which is currently characterized as "personal magnetism," and all who knew him were brought under its influence, and quickened in their aspirations after a higher and more perfect life. He was a man of great spirituality and profound devotion, but this involved no weakness, and he did not waste himself in mere fervid emotion. His judgment was clear, his criticisms telling, and his views independent. Though in the Church heart and soul, he was not a blind partisan, but saw the evils that were near, and the good that was beyond. Liberal in his ideas and catholic in his sympathies, he was unsparing in his condemnation of the selfish worldliness that he encountered in his own sect, and cordially responsive to all the noble work of the age whether within or without the pale of ecclesiasticism.

There were a simplicity, modesty, and intense earnestness in this man's nature, such as are but rarely observed. Though gifted as a preacher and capable of brilliant mental work, he never courted popularity, nor sought conspicuous positions. Often solicited to enter the higher sphere of churchly recognition and influence, he steadily resisted these importunities, preferring obscurity, and quiet, unobtrusive labor among the common people that had not been spoiled by affluence. He was very radical in his convictions in regard to ministerial duty, as may be gathered from various passages of his correspondence. In a private letter written from Boston, in 1869, he speaks very plainly: "This morning I preached in an old wealthy and dead church. To preach to such a people is like preaching to a field of old stumps and about as hopeful. . . . I thank God that we are not rich, and that our lot is not, and has not been, cast with the rich. I tell you the rich can hardly enter into the kingdom of heaven, whether they be clergy or laity. . . . I feel that we are all relying too much on money—great stone churches, fine houses, large salaries, etc., which have brought the Church to the level of the world. I see the rich, full of pride, taken up with vanity, soul all gone, thinking their gain is godliness, no sympathy, no *true* riches of any kind."

Again he breaks out: "I am more and more convinced that a hired ministry is a great evil. To preach honestly under such circumstances almost kills me; to preach tenderly is almost impossible. To take pay for preaching is base and unmanly; I feel it more and more every day. To be in the position of a divine teacher and not preach according to my conscience is impossible, and so, what with one thing and another, the difficulty of doing one's duty—the sense of begging or being a hireling—almost drives me out of the ministry. I ask myself: Is this all that eighteen hundred years can accomplish for man by the Church, and in the Church? Italy could not be worse off without her Church. How is it with the United States?"

In regard to science Mr. Perinchief was large-minded and sympathetic, although his acquisitions in this direction were of course slender. Neither his early education in the parish-school at Bermuda, nor his subsequent training at Amenia Trinity College and the New York Theological Seminary, could have been well adapted to inform him of the great truths of modern science, or to create any special interest in this line of study. But the instincts of his liberal intelligence were true to the spirit of improvement and progress, and, as his mind widened by observation and reflection, he saw clearly enough that science is to be the great renovating agency of modern times. In this relation his biographer remarks: "The scientists who wrote on evolution, as well as those who uttered striking thoughts in theology, literature, art, philosophy, or statesmanship, he devoured with equal gusto; and, discriminating between facts demonstrated to be true and those purely theoretical, he was always ready with a criticism or decided opinion on the merits of what he read. He accordingly saw nothing in science to cause alarm, but welcomed it as a grand agency of human amelioration, in emancipating men from superstition, and in making those great conquests of Nature that have been so powerful in elevating mankind from barbarism and carrying on the work of civilization. Nor could he understand how a deeper knowledge of the method and mysteries of Nature can have any other effect than to exalt and purify the conception that man forms of the Creator and Ruler of all things. His faith was not of a kind to be disturbed by any progress of knowledge. He therefore held all true men of science who dedicated themselves to the elucidation of the works of God as promoters of religion in its best and highest sense. He cheered on the labor of scientists, commending their single-minded and unswerving devotion to the pursuit of truth, not in any skeptical spirit, but as a simple dictate of Christian principle."

The illustrations of these sentiments, occurring in Mr. Perinchief's letters, are noteworthy. He was a careful reader of this magazine, and thus wrote concerning it to his friend Mr. John A. Graham, of New York: "I am exceedingly obliged to you for that copy of the 'Science Monthly'; I am much delighted with it. This is an enterprise I would very gladly see prosper in this country. It is very much needed, and I believe it will be sustained. It will help men who are now thinking along their own solitary lines; it will stimulate thought in those who have not thought before; it will gradually elevate the tone of our entire literature. If it can only get among our church people, it will make many of them more truly religious. Success to it."

Again he wrote to the same gentleman regarding two books bearing in opposite directions upon current controversies.

Draper's book is better than I expected to find it. I knew it was a *book with something in it*, but I find a *great deal* in it, and I am satisfied there is a great deal more in it than he has put in so many words upon the face of it. This book, like many others of recent origin, convinces me that there is such a thing as the *spirit of an age*, a something which turns the general mind in a given direction. It startles me a little to find, in books, things which I have dug out little by little. It startles me to find, in black and white, conclusions at which I have very reluctantly arrived, which I have tried to resist, but at last found irresistible. And there are yet other things which must come, for there is much that is "rotten in Denmark"!—other things which have made me sick in discovering them, and now make me sick in contemplating them. What changes the last twenty-five years have wrought! How much greater changes the next twenty-five years will work! All too late, however, for me personally; I was born too soon or too late. The churches, the ministry, the theology of the past will not do for the future. The new wine can not be put into the old bottles. . . .

The Duke of Somerset's book is hardly a book. There is really very little in it. It is not a spontaneous production of his, it is a mechanical collection of scraps, things somebody else has evolved; many of those things are true enough, but they lack life. Some of them are not true at all, only "my Lord Duke" don't know it. In some cases he don't even see the idea he wants to hit. He simply fires up the tree, violating Davy Crockett's first law of shooting. The work of the true seer is not destruction, but construction. If the Duke had lived fifty or a hundred years ago he would have been in his proper time. Any landsman can see the waves and the storm and the rocks, but the true pilot is the man who takes us safely past them. Men like Draper and Arnold show us a continent ahead. The Duke of Somerset only tells us there is not one behind us.

Some of Mr. Perinchief's sermons have been published, but are out of print; new editions are announced. They are remarkable for vigorous simplicity of style, warmth of religious feeling, and independence of thought. Mr. Perinchief's position in the Church was similar to that of Frederick Robertson. There is much likeness in their intellectual work, and in the opinion of many the excellences of Mr. Perinchief's discourses are quite equal to those of the eminent and liberal English clergyman.

The Arctic Voyages of Adolf Erik Nordenskiöld from 1858 to 1879. With Illustrations and Maps. London: Macmillan & Co. 1879. $4.50.

Nordenskiöld occupies an eminent position among the explorers of Arctic lands. For upward of twenty-one years, or since 1858, he has devoted his great abilities to that laborious and often perilous work. Accounts of his researches and discoveries have appeared from time to time, and the Swedish Arctic and Polar Expeditions planned by him, or in which he took a conspicuous part, have a wide fame, and are rich in results. The latest expedition undertaken by the great explorer was a successful effort to reach Behring's Strait and the Pacific Ocean from Norway by way of the Kara Sea and the Arctic Ocean. In this and in two previous expeditions along the north shores of Europe and Asia an extensive series of observations was made of the greatest importance to commerce and to science. The coast-line was well determined and mapped, soundings were made, and a record kept of meteorological and magnetical observations. Besides these, some of the great rivers which empty into the Arctic Sea were explored; the important fact was shown that the northern lands of Siberia are not only highly fertile, but are susceptible of cultivation; and that a vast pine forest of gigantic growth extends northward of the Arctic Circle, stretching from the Ural quite to the Sea of Okhotsk. Many more plants were found at home in higher latitudes in Siberia than in Sweden. The white and red currant grow in great luxuriance on the banks of the Yenisei in the north forest region.

The volume before us was prepared by Alexander Leslie, Esq., of Aberdeen, and, although largely a compilation from reports and papers by Nordenskiöld and his able scientific assistants, has been put together with rare tact and judgment, and forms an interesting and timely contribution to the literature of Arctic exploration.

The first voyage of Nordenskiöld to Spitzbergen was made in 1858 as geologist in Jorell's first expedition to that island. It was then that he discovered, at Bell Sound, on the southwest part of Spitzbergen, the remarkable fossil flora which was determined by Professor Heer to be of Tertiary age. He also found in the same fiord limestone in vertical strata, which, from its fossils, is referred to the Carboniferous formation. In the spring of 1861 another voyage was made, and the work of exploration begun in 1858 was pushed with vigor. On this journey, while yet many miles from Spitzbergen, snow-buntings, exhausted in their migratory flight, alighted in the rigging of the ship. On another occasion, flocks of the barnacle-goose were seen flying northeastward beyond Spitzbergen, perhaps to yet unknown lands. When the breeding-season for birds was at its height, the vast numbers seen astonished the travelers. The rocks of the coast for many miles were literally covered with them.

Nordenskiöld made six voyages of exploration to Spitzbergen, and one to Greenland. This last was in 1870, and the account of his journey inland is of great interest. He proceeded to the head of Auleitsivik Fiord, and went thence about thirty miles over a region that was one vast ice-field, dangerous and exhausting to travelers. They reached a point twenty-two hundred feet above sea-level. A pair of ravens were the only animals seen, but traces of the ptarmigan were met with. In the Polar Expedition to Spitzbergen in 1872–'73, a very extensive exploration of the eastern shore of Northeast Land was made. This is a desolate, ice-covered island about ninety miles in length by seventy-five in breadth, separated from Spitzbergen by a strait eighteen miles broad. The ice-covering is probably from two to three thousand feet in thickness, and the movement of the ice-mass is eastward, forming the broadest glacier known. Its breadth is even greater than that of the Humboldt glacier of Greenland.

The book abounds in fine descriptions of Arctic scenery, and the long night seems to be not wanting in agreeable aspects. The darkness is lessened by the mild light of the moon; and a faint, reddish glimmer in the southern horizon lingers for some time, a reminiscence of the day and of summer. Overhead the pole-star shines with steady luster, and the vault is all aglow with stellar light. On the shore, in the ice-slush, a phosphorescent glow is frequently observed, due, it is supposed, to the presence of minute crustaceans, and this phenomenon continues even at a temperature of 10° Cent. below freezing.

The results of Nordenskiöld's last voyage, in which he passed Behring's Strait and entered upon the Pacific Ocean, are briefly stated, and the fuller account from the pen of the explorer will be awaited with interest. The Vega, the vessel in which this important voyage was made, was detained by ice but a few miles from the strait, for two hundred and sixty-four days. It made the passage of the strait on the 20th of July last, and demonstrated the practicability of navigation from the North Atlantic to the North Pacific. The volume is appropriately dedicated to Oscar Dickson, of Gothenburg, whose princely liberality made the several expeditions possible.

An Illustrated Dictionary of Scientific Terms. By William Rossiter. New York: G. P. Putnam's Sons. Pp. 350. Price, $1.75.

Books of this kind are much needed, as our scientific literature is becoming burdened with a great multitude of new technical terms, many of which are not found in ordinary dictionaries. But this work does not profess to be complete. Only the most commonly used and most important words have been included. The compiler has aimed at accuracy and brevity, and seems to have fairly secured both. We might object to the smallness of the type, but 14,000 entries got within moderate limits of course necessitate small type.

The English Language and its Early Literature. By J. H. Gilmore, A. M., Professor of Logic, Rhetoric, and English in the University of Rochester. New York: D. Appleton & Co. Pp. 138. Price, 60 cents.

This is a small book, but a valuable one. It assumes that there is need in our schools of a much more thorough study of English, and it opens the way to this study by a rational method. The usual study of language, as an isolated and arbitrary acquisition—an accumulation of words in the memory in their mere verbal relations—is one of the driest and most repulsive of mental occupations. Grammar is undoubtedly more responsible for that hatred of the schoolroom, and all that belongs to it, which is one of the common results of education, than any other subjects. The laws of mind, like the physical laws, vindicate themselves. The young intellect instinctively revolts at the drudgery of grammatical word-grinding, and in all history the teacher tries to counteract this tendency by the use of the rod. There is no reason or necessity for this; it is simply the result of a vicious method. The subject is capable of deeply interesting all minds of sufficient maturity to begin to recognize the relations and meanings of things. As Professor Gilmore says, the study of English literature "may be made one of the most interesting by associating the literary with the political and social history of the people; by withdrawing attention from the minute details of literary history, and fixing it only on salient points; by studying authors as well as studying about authors." The professor cuts the knot at once by taking the evolution point of view. He says: "We propose, then, to consider the origin and development of the English language; and to approach that subject—as, indeed, it can only be intelligently approached—from an ethnologic and historic point of view. In studying the philology of a people, we *must* at the same time study their ethnology and history. We can have no just conception of English literature unless, as we trace its progressive development, we couple with it the gradual unfolding of English political and social life." He goes on in the same strain; "The present *character* of a people is largely determined by the character of their ancestors, and the circumstances in which those ancestors were developed. The *political institutions* of a people are but the unfolding of a germ implanted centuries ago, and matured by all the influences to which that people has since been subjected. So it is with the *literature* of a people. All the past enters into the present, and makes it what it is. The present will enter into all the future, and give it character. A nation's literary history records the germination and growth, through shade and sunshine, of seeds which were implanted in the soil centuries ago—the development of principles which are as old, to say the least, as the language in which they are to-day embodied. Hence, to apprehend fully the literary character of any age, we must submit ourselves to the formative influences which have made its literature what it is. Thoroughly to understand the dramas of Shakespeare, the essays of Bacon, the poems of Milton, we must go back into the dim and dusty past, and learn how Shakespeare, Bacon, and Milton came to think and speak as they did; for no one even of these master minds was sufficient unto himself—they were all more or less indebted to the past. What has been said with reference to English literature is equally true—indeed, rather more true—with reference to the English *language*. In order thoroughly to comprehend and effectively to use the English of the present day, we must study the English of the past—we must know the language, not merely in its developed form, but in its germinal principles."

The book is obviously the result of wide and critical reading, and much experience in teaching. It makes no formal claim as a text-book, but competent instructors will find ways to make it useful. It contains copious notes, and many references to works suitable for consultation by students.

Darwinism and Other Essays. By John Fiske, A. M., LL. B. Macmillan & Co. Pp. 283. Price, $2.

This volume consists of various articles contributed by its author to the periodicals, and he has done well to collect them in this convenient and accessible form. The book opens with three or four papers on various aspects of "Darwinism," but its chief contents are not described by this title, though they all treat of kindred questions raised by the progress of recent inquiry. Although not a systematic treatise, this collection will be valuable to students of contemporary thought. It may be strongly commended to general readers upon those subjects, as introductory to more methodical works. The book is in an eminent degree of the explanatory and helpful sort which, by brief incidental explanations, often succeeds in aiding the learner where more formidable disquisitions fail to be apprehended. All who are perplexed with imperfect apprehension of evolutionary doctrines will find these essays especially instructive and useful. They are not only full of valuable thought, but they make the topics plain and interesting to unproficient minds.

Memoirs of the Science Department, University of Tokio, Japan. Vol. I., Part I. Shell-Mounds of Omari. By Edward S. Morse, Professor of Zoölogy, University of Tokio. Published by the University of Tokio, Japan. Nisshusha Printing-Office. 2539 (1879).

This monograph of Japanese archæology has much more than the usual interest of such documents. In the first place, it emanates from a university that has recently arisen in the great city of Tokio, which has a vigorous scientific department, and is filled with native students, who are pushing with enthusiasm into the field of original work. Several English-speaking professors have been called to take positions in this institution—the heathen being apparently more appreciative of the missionaries of science than the missionaries of the gospel. Professor Morse, of Salem, who has for the past two or three years been carrying on the good work of zoölogy in the Tokio University, has also interested himself in Japanese ethnology and the relics of its old civilization. It is curious that, when we get back sufficiently far in time, modern distinctions disappear, and we are lost in a prehistoric antiquity which discloses common features all over the world. The mound-deposits of Japan early attracted Professor Morse's attention. He had already studied these phenomena in Massachusetts and Maine, with Wyman and Putnam, and was prepared to keep a sharp lookout for evidence of their occurrence in the East. Soon after his arrival he fortunately discovered a large and extensive shell-mound on the line of the railway at Omori, six miles from Tokio. The students of the university joined him in exploring it, and many interesting specimens of pottery, implements, and weapons were obtained, which are preserved among the collections of their Archæological Museum in Tokio. The present memoir is descriptive of those specimens. Appended to the text of this memoir are eighteen large lithographic plates on folding pages, and containing two hundred and fifty illustrations of archæological subjects. These lithographic representations are excellently done, and were all drawn by Japanese artists. Nor is this all: the composition and press-work of the volume are the work of Japanese printers, the type being set by compositors unable to speak a word of English. And, what is more, the paper upon which the book is printed is of Japanese manufacture. The paper is superior, the typography excellent, and the printing first rate—in fact, for a "heathen" production the work is highly creditable.

Fuel: Its Combustion and Economy. Edited by C. Kinnard Clark, C. E. D. Van Nostrand. Pp. 394. Price, $1.50.

This volume is a combination of two works, one by C. Wye Williams and the other by J. S. Prideaux, on the general subjects of the combustion of coal, the structure of furnaces, and the atmospheric conditions of high thermal effects. It is fully illustrated, and forms a very complete manual of the subject.

Units and Physical Constants. By J. D. Everett, F. R. S. Macmillan & Co. Pp. 175. Price, $1.10.

This is a valuable digest of what may be called the data of the physical sciences—the units, constants, standards, and symbols of the foundation facts of the most important branches of physical science—mechanics, hydrostatics, astronomy, sound, light, heat, magnetism, and electricity. Treating of the basal conceptions of quantitative science, its expressions are of course in mathematical form. It is a valuable book for critical students, and done by a first-class man.

Solar Light and Heat: the Source and Supply. Gravitation; with Explanations of Planetary and Molecular Forces. By Zachary Allen, LL. D. D. Appleton & Co. Pp. 241. Price, $1.50.

Dr. Allen published an elaborate work in 1851, entitled "The Philosophy of the Mechanics of Nature." The present volume is a sequel to that publication, and, besides embodying its results, it involves further researches into the origin of molecular forces, of gravitation, and also of solar light and heat. The author's fundamental idea is, that molecular forces have their origin in the mechanical motions of great masses of matter; or that the heat, light, and radiant energy of space, acting upon the earth to produce all its activities, originate in the rotary and orbital movements of the sun and planets. The radiant forces are engendered and transmitted by means of a universal, electric, ethereal medium; and a large portion of his volume is devoted to an elucidation of electrical effects and laws which go to prove that the solar system is a mighty electric and electro-magnetic engine. Dr. Allen's views are comprehensive and interesting; it is for physicists to judge of the evidence of their validity.

First Book of Qualitative Chemistry. By Albert R. Prescott, Professor of Applied Chemistry in the University of Michigan. Van Nostrand. Pp. 160. Price, $1.50.

This volume has been prepared primarily for use under teachers who also employ the author's larger work upon Qualitative Analysis. It is, therefore, a working laboratory-book, useful for classes who desire to take a short course in practical, qualitative chemistry. It is designed to afford as much insight as possible into chemical action, and prepares for a more definite study of acids and bases than is usual in such rudimentary books. The name of the author gives assurance of the excellence of the work.

Electro-Metallurgy practically treated. By Alexander Watt, F. R. S. S. A. D. Van Nostrand. Pp. 195. Price, $1.

Here is the sixth edition of a technological hand-book, the merit of which is thus fully attested; for those who have bought it are naturally those who wanted to use it, and it has thus been subjected to the sharpest trial. It describes the processes of electro-gilding, electro-plating, and coating of surfaces by electro-deposition; and is full of the information required by the artisan in this field of industry. The volume is an interesting record of recent improvements, and is especially full in details concerning the electro-deposition of nickel, which is just supplanting silver as a protective and ornamental coating for other metals.

PUBLICATIONS RECEIVED.

The Californian. A Western Monthly Journal. Vol. I., No. 1. January, 1880. San Francisco: The A. Roman Publishing Co. Pp. 100. 25 cents a number, $3 a year.

Industrial Education, or the Equal Cultivation of the Head, the Heart, and the Hand. An Address, by Professor Alexander Hogg, before the National Educational Association at Philadelphia, July 31, 1879. Pp. 15.

Mathematics in a Dilemma. By Lawrence S. Benson. New York: W. T. Hyde & Co. 1879. Pp. 17.

Prospectus of the Manual Training School of Washington University. St. Louis, Missouri: Globe-Democrat Printing Co. November, 1879. Pp. 24.

The Relation between Language and Ideas. A Lecture by M. A. Clancy, before the Teachers' Institute of Alexandria, Virginia, September 19, 1879. Pp. 27.

Sermons of M. J. Savage. Series on the Morals of Evolution. VII. The Relativity of Duty. Pp. 19. VIII. Real and Conventional Virtues and Vices. Pp. 16. Boston, December 12, 1879.

Notice of New Jurassic Mammals. By Professor O. C. Marsh. Reprinted from "American Journal of Science and Arts." December, 1879. Pp. 5. Illustrated.

Legends of Sepulchral and Perpetual Lamps. By Professor H. Carrington Bolton. London, 1879. Pp. 9.

Report of the Committee on Correspondence appointed by the New York State Association of School Commissioners and Superintendants, on Modes of School Supervision and Administration in the Schools of the State. Pp. 60.

Sensibility, Intelligence, Instinct, and Mind. By A. J. Howe, M. D. Cincinnati, 1879. Pp. 8.

The Berkeley Quarterly. A Journal of Social Science. Published by the Fortnightly Club, Berkeley, California. Vol. I., No. 1. January, 1880. Pp. 80. 50 cents a number, $2 a year.

Eighth Report of the State Entomologist on the Noxious and Beneficial Insects of Illinois. By Cyrus Thomas, Ph. D., State Entomologist, Springfield. 1879. Pp. 212, with Index.

Double-Star Observations made in 1877–'78 at Dearborn Observatory, Chicago, comprising: I. A Catalogue of 251 New Double Stars, with Measures; II. Micrometrical Measures of 500 Double Stars. By Sherburne Wesley Burnham. Reprinted from the Memoirs of the Royal Astronomical Society. Pp. 167.

How to study Phrenology, including the First Principles or Outlines of Phrenology. By H. S. Drayton, A. M. New York: S. R. Wells & Co. 1880. Illustrated.

The Workshop Companion: A Collection of Useful and Reliable Recipes, Rules, Processes, Methods, Wrinkles, and Practical Hints for the Household and the Shop. New York: The Industrial Publication Company. Pp. 164. 35 cents.

Genesis I.-II.: An Essay on the Bible Narrative of Creation. By Augustus R. Grote, A. M. New York: Asa K. Butts. 1880. Pp. 82. 50 cents.

Theology and Mythology: An Inquiry into the Claims of Biblical Inspiration and the Supernatural Element of Religion. By Alfred H. O'Donoghue. New York: Charles P. Somerby. 1880. Pp. 194.

The Art of Cooking: A Series of Practical Lessons. By Matilda Lees Dods, of the South Kensington School of Cookery. Edited by Henrietta de Condé Sherman. New York: G. P. Putnam's Sons. 1880. Pp. 226. $1 25.

The Younger Edda; also called Snorre's Edda, or the Prose Edda. With an Introduction, Notes, Vocabulary, and Index By Rasmus B. Anderson, Professor of the Scandinavian Languages in the University of Wisconsin, etc. Chicago: S. C. Griggs & Co. 1880. Pp. 302. $2.

Report of the Director of the New York Meteorological Observatory Department of Public Parks, City of New York, for the Year ending December 31, 1878. Illustrated. New York, 1879. Pp. 70.

Zoölogy for Students and General Readers. By A. S. Packard, Jr., M. D., Ph D. With numerous Illustrations. New York: Henry Holt & Co. 1879. Pp. 719. $3.

POPULAR MISCELLANY.

Geology of the Far West.—Last summer Professor Geikie, of the University of Edinburgh, came over here to study the geology of our Western Territories, the remarkable peculiarities of which have excited much interest abroad; and he has recently made his explorations the subject of a very interesting lecture before his class. From a summary of the discourse, published in "Nature," we gather the following instructive particulars: Professor Geikie had three objects in view in the expedition: 1. To study the effects of atmospheric and river erosion upon the surface of the land; 2. To mark the relation which the structure of the rocks underneath bore to the form of the surface; and, 3. To watch some of the last phases of volcanic action. In crossing the prairies toward the Rocky Mountains he noted the singular fact that their surface was "veneered" with a thin coating of pinkish, fine-grained sand, its color being due to small pieces of fresh feldspar. It was clear that this mineral, as well as fragments of quartz and topaz found with it, did not belong to the strata on which they lay. In going west, the grains of sand, getting coarser, assumed the form of distinct pebbles, and on reaching the mountains became huge blocks and bowlders, evidently derived from the heights beyond. The name, "Rocky Mountains," the Professor regards as singularly misapplied. On most maps of North America a continuous line of lofty ridge is represented as extending down the axis of the continent, and marked "Rocky Mountains." No such ridge, however, is to be found. The great plateau had been wrinkled by numberless meridional folds, which, dying out, have been replaced by others. Some of these folds form mountain-ranges with wide basins between them. It is, however, possible to cross the axis of the continent without climbing over mountains of any kind, and the Union Pacific Railroad follows one of these natural routes. So little did the landscape suggest great altitudes that at an elevation of eight thousand feet a wooden placard had been erected, bearing the title "Summit of the Rocky Mountains." Going westward to Denver, the Professor halted on the borders of the great mountain-range that forms the bulwarks of the parks of Colorado. These crests of crystalline rock have been forced up like a great wedge through the cretaceous and tertiary strata of the prairies, carrying the latter up with them in a grandly picturesque curve along their flanks. An excursion into some of the mountain gorges or cañons brought to light the source of the pink feldspar sand of the prairie; great masses of pink granite, gray gneiss, and feldspar form the core of the mountains; these are visibly crumbling into the same kind of pink sand and gravel. The mountains have been covered with glaciers which have flowed out into the plains, and there shed their huge horseshoe-shaped moraines. Having crossed the watershed of the continent, Professor Geikie struck westward into the Uintah Mountains, one of the few ranges in that region that has an east and west direction. It forms one of the most remarkable elevations in North America. Unlike the other mountainous high grounds it possesses no great central core of crystalline azoic rocks, but consists of a vast flattened dome of red sandstones, dipping steeply down beneath mesozoic rocks on either flank. One feature of surpassing interest in the Uintah Mountains is the evidence of enormous denudation, continued through a protracted cycle of geological time. The horizontality of the strata along the central parts of the range is such that terrace above terrace can be traced by the eye for miles around any commanding peak. The rocks there have escaped crumbling and fracture to a remarkable degree. It can therefore be seen that the deep gullies and clefts, the yawning precipices and cañons, the wide corries and vast amphitheatres by which the surface is so broken up have been produced not by underground disturbances but by erosion at the surface. Most of this tremendous denudation has doubtless been effected by ordinary atmospheric action. One of the valleys in this section he describes as crossed by beautiful horseshoe moraines that had once formed a succession of lakes, the sites of which are now occupied by meadows. In these and other high grounds, the beaver, by its dams, has converted the small streams into a succession of shallow lakes, and hundreds of acres of bog-land have been thus produced. The grand cañon of the Yellowstone, gouged out of volcanic formations, Professor Geikie described as exhibiting, perhaps, the most marvelous piece of mineral color to be seen anywhere in the world. It has been cut out of tuffs and lavas, showing sulphur-yellow, verdigris, or emerald-green, vermilion, crimson, and orange tints, so remarkable that, if transferred to paper or canvas, they would be pronounced incredible and impossible. In the Yellowstone Valley abundant evidence of extensive glacial action was found. On entering the second cañon in their ascent of the valley, it was seen to be most exquisitely glaciated from bottom to top, thus making it clear that the cañon was older than the glacial period; it had supplied a channel through which the glacier had ground its way out from the mountains. According to the indications on the sides of the valley, this glacier must have had a thickness of sixteen or seventeen hundred feet. The Professor next described the famous geyser region. The ground was honeycombed with holes, filled with boiling water. One geyser, known as "Old Faithful," went off with wonderful regularity every sixty-three minutes; the others were more variable. The "Devil's Paint-Pot," a mud-geyser, boiled like a great vat of thick porridge, throwing out white and brilliantly colored mud. Professor Geikie acknowledges with admiration the labors of the explorers who first made known the wonders of this remote and inaccessible region. The reports of Hayden and his associates were found to be most trustworthy and useful. Nor could one forget the sagacity with which Hayden proposed, and the enlightened liberality with which Congress enacted, that for all time the Yellowstone region should be a tract set apart as a national park for the instruction and recreation of the people. On reaching the basin of the Great Salt Lake, our traveler was impressed, by the evidences on every hand of the former vast extent of this inland sea. Lines of terrace ran along the sides of the mountains, the highest standing a thousand feet above the present level of the water. The rocks in some of the cañons descending from the Wahsatch Mountains, in the Salt Lake Basin, were found smoothed, polished, and striated by the glaciers that had come down from the heights above, bringing with them great quantities of moraine matter. Mounds of rubbish blocked up the valleys here and there, and some of them were observed to descend to the highest terrace. Hence, when the Salt Lake extended far beyond its present area, and was about one thousand feet deeper than now, the glaciers from the Wahsatch Mountains reached its edge, and shed their bergs into its waters. Bones of the musk-ox had been found in one of the terraces, showing that Arctic animals lived in this region during these cold ages.

Death of Professor B. F. Mudge.—We have to record the death, at his home in Manhattan, Kansas, on the 21st of November last, of Professor B. F. Mudge, whose geological and paleontological researches and writings had gained for him a high place among Western men of science. Professor Mudge began his working life at the age of fourteen as a shoemaker, but at twenty fitted himself for college, and entered Wesleyan University, where he graduated in 1840. He then studied law; was admitted to the bar in 1842, and for the next seventeen years practiced his profession in Lynn, Massachusetts, of which city he was elected the second Mayor. In 1859 he went West, and took the position of chemist for the Breckenridge Oil and Iron Company in Kentucky. When the war broke out he removed to Kansas, and in 1863 received the appointment of State Geologist. In 1865 he was elected Professor of Geology and Associated Sciences in the State Agricultural College, a position he continued to fill for eight years. Since 1874 Professor Mudge has thoroughly explored the geology of Kansas, describing for Professor Hayden the Tertiary and Cretaceous formations of the State, and making extensive collections for Professor Cope, including among other interesting fossils the discovery of one of the earlier if not the earliest specimen of toothed birds found in this country. More recently he was employed by Professor Marsh as field geologist of Yale College, and has since made large collections in the West for the Peabody Museum. Professor Mudge was a member of the American Association for the Advancement of Science; and was one of the founders of the Kansas Academy of Sciences, and its first President. He also took a deep interest in the cause of general education, and was offered the position of State Superintendent of Schools in Kansas; this, however, he felt obliged to decline, in obedience to his preference for active scientific work. Indefatigable as an observer, Professor Mudge was also a clear and interesting writer; and it is to be hoped that his numerous scientific papers will yet be brought together for permanent preservation in book-form.

Zoölogical Work at the Chesapeake Laboratory.—In a brief report to the President of Johns Hopkins University, Professor W. K. Brooks, of that institution, gives an interesting outline of the investigations carried on during the past summer in the Chesapeake Zoölogical Laboratory of which he was in charge. The laboratory opened at Crisfield, on the eastern shore of the bay, June 25th, having its quarters in three barges belonging to the Maryland Fish Commission. There were a dozen gentlemen in attendance, most of them trained observers, and the amount of work accomplished during the session Professor Brooks describes as very satisfactory. Later in the season the mosquitoes made the barges uninhabitable, and the party was obliged to move to Fort Wool, where its work was continued until September 15th, making the length of the session eleven weeks. Dr. S. F. Clarke, assistant in the Zoölogical Laboratory of Johns Hopkins, devoted most of the season to the study of hydroids, and found that many of the species which occur in the bay are new to science. Besides describing a number of these, he was able to make important observations on their structure, manner of growth, and other points of interest. Professor E. A. Birge, of the University of Wisconsin, made a very complete series of observations on the larval stages of two genera of crabs, tracing them from the egg to the adult form; and prepared a full set of drawings showing each appendage at each stage of development. A careful study of the development of the edible crab was attempted, but stormy weather prevented a completion of this work, which it is suggested should be taken up again another season. Concerning his own investigations, which were mainly directed to the development and artificial propagation of the oyster, Professor Brooks states that he obtained information on a number of obscure points in molluscan development, and also reached very unexpected conclusions regarding the breeding habits of the American oyster which he believes will prove to be of great economic importance. Owing to the difficulties attending such investigations at the ocean, much of the work begun was left incomplete; several of the researches, however, were carried far enough to warrant publication, and a number of papers have been prepared that are now ready for the press.

Progress of the Electric Light.—Mr. Edison has been vigorously prosecuting his investigations in relation to this subject, in the laboratory at Menlo Park, and has lately announced an important step forward. His task has been to get an electric lamp that would work satisfactorily in giving out only the light of a common gas-burner. The carbon-points and arc would not answer. He labored a long time to make platinum in some form serve as the wick of his lamp, to be made luminous by the current. But, this failing to meet his requirements, he cast about for other materials. He tried carbon in various shapes, and at length hit upon one form of it which he thinks promises to solve his problem successfully. He cuts out a slender piece of paper from cardboard, in the shape of a horseshoe, about one inch and a half long, and not thicker than a knitting-needle. This is then carbonized by pressing it between metal plates, which are raised to a high temperature. This little slender carbon-loop, which preserves its fibrous character, so as to make it somewhat elastic, is clamped to the conducting wires, at each end, and is then introduced into a little glass globe, two or three inches in diameter, which is exhausted of air, and immediately sealed up. By improvements in the Sprengel pump, Mr. Edison claims to get a vacuum so perfect that but one millionth of the air remains in it. As the current passes through the carbon it heats it to a glowing whiteness, so that it gives out a very pleasant, moderate light. These lamps, it is said, can be made very cheaply, and it is claimed that thus far the carbon filaments withstand the influence of the current and promise to be permanent. It would, of course, be premature to pass judgment upon that which time alone can determine.

About Snakes.—The question how snakes progress is answered by the books in a way satisfactory to many minds, but Mr. H. F. Hutchinson, who writes about them in a recent number of "Nature," takes some exceptions to the usual explanation. He seems to have been a careful observer of their habits, and concludes that terrestrial snakes move in one or the other of the following ways: "1. On smooth, plane surfaces, by means of their rib-legs; e. g., the boa. 2. Through high grass, by a rapid, almost invisible, sinuous onward movement, as the hydrophidæ in water; e. g., the rat-snake. 3. Climbing trees, or ascending smooth surfaces by erecting their abdominal scales, or using them to produce a vacuum, as lizards do their foot-scales for ascending smooth surfaces; e. g., tree-snakes and cobras." Mr. Hutchinson captured a snake nine inches long, with a head less than half an inch broad, and presented it with a frog two inches long and one broad. The snake saluted the frog by seizing it by the nose. The animal made desperate attempts to shake it off, but in vain, and all the while the process of deglutition (?) was going on, or rather the snake was slowly but surely getting outside the frog. This was accomplished by a sort of vermicular process. The sharp little teeth were seen to advance slightly, and then the whole body wriggled up to a new hold on the frog. In this way it very gradually disappeared, the whole process lasting half an hour. The so-called snake-charming Mr. Hutchinson is confident is only clever *legerdemain*. He describes the operation of skin-shedding as follows: "The skin ready to be cast yields round the snake's mouth only, and remains adherent to the extremity of the tail. As the animal advances, the caudal extremity of the skin is inverted—that is, pulled inward—and so the process goes on, and is completed by the tail passing through the mouth of the skin; and thus the direction of the abandoned skin is directly opposite to the direction taken by the skin-casting snake—that is, if the mouth of the skin lies east, the snake went out to the west."

Improvements in Butter-making.—English farmers of late years have been giving more and more attention to the improvement of their dairy products, and in the business of butter-making, especially, have made some very considerable advances on the old-time practice. One of the most recent and one of the most important of these is the discovery of an odorless, tasteless, and quite innocuous antiseptic that proves to be an effectual preservative of butter, without the use of salt, and without the usual precaution of excluding it from the air. To test its efficacy, the patent was submitted to Mr. G. M. Allender, a disinterested expert in London, for trial. On the 24th of July last he treated a churning of butter in accordance with the directions specified, and, inclosing the butter in a muslin cloth, placed it in a firkin without a particle of salt—every precaution being taken that there should be no tampering with the experiment. The firkin remained on the premises at St. Petersburg Place, Bayswater, for three months, and when examined on October 24th the butter was as sound and sweet as when first put in, although during the whole time it had practically been exposed to the air, nothing having been done to exclude the latter from the firkin. Without treatment it would undoubtedly have become wholly putrid in that length of time; nothing, however, could be detected by either smell or taste to indicate that the sample had suffered the slightest deterioration, as it possessed all the qualities of flavor and firmness of butter churned the day before. Experts in different parts of the country were furnished samples, and all pronounced the preservation wonderful; they were of the opinion, however, that the best, newly-made butter has a peculiar aroma that is not quite equaled in the preserved butter, while the latter was considered a little "dead," a defect that is removed by the addition of one per cent. of salt. The cost of the preservative does not exceed one halfpenny per pound of butter; it is worked in directly after churning, and requires no further care or attention, except that, like other butter, it should be kept in a moderately cool place.

Are Bacteria found in Healthy Animals?—In the "Journal of Anatomy and Physiology" for April, 1878, Messrs. Chiene and Ewart asserted that bacteria did not exist in the organs of healthy living animals. In the August number of the "Journal für Praktische Chemie" Messrs. Neucki and Gracosa urge the affirmative side of the question. The chief points of the latter's argument we abstract from a recent copy of "Nature": Dr. Burdon-Sanderson plunged an organ from a newly-killed animal into paraffine heated to 110°, it was allowed to cool and then covered with Venetian turpentine to still further protect it from outside infection. Two days after, the organ was found in a clotted and slightly cooked condition on the outside, but bacteria were present in the center. To this, Messrs. Chiene and Ewart replied that the bacteria-germs fell upon the organ in the interval between its extraction and the moment of plunging it into paraffine. This was accordingly guarded against by an antiseptic method, and three days afterward, when the specimens were examined, no bacteria were discovered. The conclusion, therefore, of Messrs. Chiene and Ewart was that, if the organs were treated antiseptically after death, neither bacteria nor their germs will be found; and hence that no bacteria-germs exist in living healthy organs. Messrs. Neucki and Gracosa, in order to prove the contrary, filled a large glass test-tube with mercury, closed it with a slip of glass, and inverted it in a vessel containing mercury. The vessel was then heated until the tube was one third filled with vapor of mercury. It was then allowed to cool; the quicksilver in the tube again condensed; and when that in the outer jar was heated to 120° it was covered with a five per cent. solution of carbolic acid. A portion of an internal organ from an animal recently killed was brought by means of a pair of tweezers under the mouth of the tube, up which it ascended. The apparatus was kept for several days at a temperature of 40°; and bacteria were subsequently found in the specimen. All experiments of this kind led to the conclusion that bacteria exist in the organs of living healthy animals.

Antiquity of Man.—Professor Boyd Dawkins, in a paper on the antiquity of man, read before the Sheffield meeting of the British Association, said that when he examined the great divisions of the Tertiary period in their relation to the highest forms of life, he was confronted by the following important facts: In the Eocene age there was not a single species of placental mammal. There is not a single well-authenticated case of any mammalian species, now living on the earth, having lived in the Miocene age, although the French archæologists claim that man lived then. In the Pliocene age one or two living species make their appearance. Passing to the Pleistocene or Glacial period, living species are very abundant, extinct species are rare. It is in this period that man appears, over an extended area. He is a mere hunter, not a farmer or possessor of wild animals. The prehistoric period which succeeded the Pleistocene was characterized by the absence of the extinct species of mammalia, with the single exception of the Irish elk. At this time, the domestic animals, the dog, sheep, horse, and various breeds of cattle appear, and are subject to man; and along with them there was the cultivation of the arts of agriculture. In conclusion, he claimed that hopes of fixing the exact antiquity of man would be vain, as there were intervals of the length of which we have no record; but he was certainly an inhabitant of the earth during the Glacial period.

Does Sargassum vegetate in the Open Sea?—In reply to the questions of a correspondent in "Nature," regarding sargassum, Mr. J. J. Wild gives the following information: While on board the Challenger, during her cruise in the North Atlantic in the year 1873, he had frequent opportunity for observing this alga, and more than once saw large patches of it extending from the vicinity of the vessel to a great distance. As regards the appearance of these sargassum patches, he quotes Sir C. Wyville Thomson, who says: "They consist of a single layer of feathery branches of the weed (*Sargassum bacciferum*), not matted, but floating nearly free of one another, only sufficiently entangled for the mass to keep together. Each tuft has a central brown, thread-like, branching stem, studded with round air-vesicles on short stalks, most of those near the center dead and coated with a beautiful netted white polyzoön. After a time vesicles so incrusted break off, and, when there is much gulf-weed, the sea is studded with these little separate white balls. A short way from the center toward the ends of the branches, the serrated, willow-like leaves of the plant begin, at first brown and rigid, but becoming further on in the branch paler, more delicate, and more active in their vitality. The young fresh leaves and air-vesicles are usually ornamented with the stalked vases of a *campanularia*. The general color of the mass of weed is thus olive in all its shades, but the golden olive of the young and growing branches greatly predominates." Mr. Wild still further quotes from the same author to the effect that sargassum is the "one notable exception" to the rule that the higher algæ do not live on the surface of the sea. Mr. H. N. Moseley, in "Notes by a Naturalist," refers to the pelagic habits of sargassum and other sea-weeds when he says, "They grow attached to rocks, as well as free, but they all produce spores only when attached."

The Salmon Industries of Oregon.—It is well known that the salmon, which is esteemed a luxury, and at certain seasons of the year is found only on the tables of the rich, is a prolific fish. A female will yield about a thousand eggs for every pound of her weight, but, of the millions of eggs deposited in spawning-beds, only a few develop to adult salmon. Numberless ova escape fertilization, floods carry them from their places of deposit, and enemies destroy both eggs and fish. Enthusiasts in fishery economy assert that in the near future salmon will be as cheap as other fish. At present, however, it is very dear, and, notwithstanding that artificial spawning is resorted to, the fish does not increase in proportion to the increasing demand. This keeps up the price, and has given rise to an important industry in the preparation of canned salmon. We glean the following concerning this industry from "Chambers's Journal": A surprising trade in this commodity has developed in Oregon, and large quantities of canned fish are exported from this source to Great Britain and Europe. Scotland and Ireland yield excellent salmon, but the canned fish may be obtained even in remote towns of the United Kingdom for half the price of the fresh. There are flourishing canneries on the Umpqua, Fraser, Royal, and Columbia Rivers. In some of these a capital of fifty thousand dollars has been invested, and twice that outlay will be required for some newly projected establishments. The fish taken from the Columbia River are nearly all 'canned,' and as many as twelve million pounds of salmon have been taken from this source in a single season. The Columbia is a river of vast extent, with an enormous body of water. Salmon run up to a distance of four hundred miles from the sea, and thus obtain ample living and spawning room in shallow places of the main stream and its tributaries. The fish selected for canning is locally known as the 'chinook salmon.' Its average size is twenty-two pounds. When taken only for local consumption, clubs and spears, or hook and line, serve the purpose; but, in order to supply the now enormously increased demand, drift-nets are used. These are three quarters of a mile in length, twenty feet in depth, and have a mesh sufficient to allow the head of a fish to enter as far as the gills. The fishing-season lasts from April to July, and during this time the work is prosecuted with vigor. Everything required in the business is manufactured on the premises. Foreigners are employed to do the work; Italians capture the fish and Chinamen prepare it for consumption. The fish, placed in racks in quantities, at the entrance of the cannery, are readily accessible. A flexible water-pipe directs its searching flow of water on to the salmon to cleanse them, after which they are sorted and placed within reach of the first operator. He takes off head, fins, and tail; making an incision into the back, the intestinal matter is removed, and the fish thrown into a tub half filled with water. The second operator scrapes and washes it, and passes it on to man number three for inspection. The fourth person ranges the bodies in a trough, where by means of blades driven by a crank they are cut to pieces. These are now neatly packed in cans, a spoonful of salt is put into each one, the lid is soldered down, and the cans are then ready for the cooking-house. Here immersed in a huge steamer they cook an hour. Removed from the steam-bath, they have each a small hole bored in them, to admit of their quickly cooling. The tins are next placed in boiling salt water, where they remain two hours. They are again examined, now to see that the ends have assumed a concave shape. Such tins as have not taken this shape are condemned, while all others are passed forward to be varnished and labeled. Before being sent to market they are again examined, and imperfect cans are rejected.

Voice in Fishes.—Mr. S. E. Pool, in a late number of "Nature," gives an account of an interesting observation of his own in support of the claim that fishes possess a faculty of voice. He states that, when engaged in a survey of the "Disang River in eastern Assam" some six years ago, he had occasion to sound the depth of a pool. When seated in a small canoe and slowly nearing it, he suddenly became aware of the presence of a number of fish called "mahsir." They were evidently attracted by the canoe, and Mr. Pool surmised that they might possibly think it a huge dead fish. While watching their movements, he became "aware of a peculiar 'cluck' or percussive sound—frequently repeated, on all sides, and coming from below," but near by. This was soon traced to the mahsir, and one of them made distinct sounds which were answered by others. He further states that in some parts of eastern Assam a large bivalve sings in concert with others.

Expansion of Bodies by Electrification.—In a communication to the Paris Academy of Sciences, E. Duter describes some experiments which have led him to the conclusion that bodies are increased in bulk by electrification. A large thermometer-tube is filled with water and coated externally with tin-foil, forming a Leyden-jar or condenser, with the water for the interior conductor, the foil for the exterior conductor, and the tube for the insulator—a platinun wire dipping into the water as a charging rod or electrode. As soon as the jar is electrified the water sinks to a lower level, and so remains till the jar is discharged. The inference is, that the glass is dilated by electrification, and this inference is strengthened by the fact that the same effects are produced whatever be the nature of the armatures, whether tin-foil, water, saline or mercury solutions. To remove all doubts, M. Duter modified the apparatus by placing the tube (or Leyden-jar) in a closed envelope of glass, terminated also by a thermometer-stem and filled equally with a liquid conductor. In this arrangement the liquid of the internal reservoir formed the interior armature of the condenser, and the liquid of the envelope formed the exterior armature, the glass tube being, as before, the insulator. On electrification, while the inner liquid sank, the outer liquid rose to an equal amount, thus proving the accuracy of the inference. On discharge of the electricity, the original levels were restored. The conclusion is, that the internal capacity of a Leyden-jar and its external volume are increased by charging it with static electricity. Temperature can not cause this change, since the effect is immediate in charging and discharging. Neither can electric pressure cause it, because that must be the same on both sides of the dielectric, and a diminution of volume would be the result. Again, it is not due to the polarity of the armature, for on reversing the poles the effect is the same.

Sheep poisoned at Pasture.—If we regard the masses of its bloom, and the exceptionally exquisite form of its blossoms, probably no flower can equal the kalmia, or American laurel. All this is appreciated in Europe, and the plant holds a distinguished place in its gardens. But at home this fine shrub bears the execration of all shepherds and herdsmen, as it is poisonous to the sheep. Next to Australia, if not equal, in sheep-raising, is Colorado. Unhappily, a poisonous mallow (*Malvastrum coccineum*) is found growing from Iowa across the great Plains westward. Last October a sheep-raiser named Ruble, in Pueblo, Colorado, had the ill luck to have a flock get into a patch of this terrible weed, and twelve hundred sheep perished in four hours! Another plant in Colorado, the dreaded "loco" of the stock-men—the *Oxytropis Lamberti*—is also noted for its poisonous qualities.

A Precocious Century-Plant.—There is now (January) a fine century-plant (*Agave Americana*) in full bloom, in the conservatory of John Hoey, Esq., at Hollywood, Long Branch, New Jersey. This plant is only twelve years old. The notion of this aloe only blooming when a hundred years old is simply a tradition of the elders. It all depends on the environment and chiefly temperature. Blooming at the age of fifty years is common. To get the plant into bloom at twenty-five years is considered quite satisfactory by the gardeners, but this instance of one flowering at twelve years, in a conservatory, must be accounted as unique.

The Proportion of Oxygen in the Upper Air.—Though oxygen is heavier than nitrogen, and therefore ought to fall to a lower level in the atmosphere than the latter gas, still, no difference has ever been found to exist in the relative proportions of the two, even at the greatest attainable altitudes. Up to such elevations the agitation of the air suffices to keep its components uniformly mixed. Whether there is any want of uniformity at still greater elevations is an open question, the solution of which has been attempted by Professor Edward W Morley, of Hudson, Ohio. Accepting as provisionally correct the theory proposed a few years ago by Professor Loomis, that great and sudden depressions of temperature are sometimes owing to the vertical descent of cold air from elevated regions of the atmosphere, Professor Morley inferred that samples of air taken at the earth's surface during a great and sudden lowering of temperature might have come from altitudes where the proportion of oxygen had been lessened by the action of gravity. He has therefore made numerous analyses of air during "cold waves," and the result has been invariably to show deficiencies in the proportion of oxygen in the air at such times.

New Coloring Matters.—The chemists Savigny and Colineau have discovered a method of obtaining innocuous coloring matters from the red cabbage. This substance is known as cauline, and is useful in painting, for printing fabrics, and for dyeing. The process is as follows: Cut the interior of the cabbage and the stalks of the leaves in small pieces and place them in boiling water in the proportion of one and a half kilogramme of leaves to three litres of water. The infusion is left about twenty-four hours to macerate, then the leaves are taken out and submitted to pressure to squeeze out the water, which is added to the liquid infusion; this cauline is of a violet-blue color. It forms the base of a series of derivatives which constitute the precipitates of various colors. For instance, to obtain *barucauline*, two grammes of baryta are added to five hundred grammes of cauline cold; this produces a clear green dye. To obtain *chlorocalcicauline*, which is a bluish green, one hundred grammes of anhydrous chloride of calcium are added to half a kilogramme of cauline. A false bronze color is obtained by adding one hundred to five hundred grammes chloride manganese and five grammes baryta to five hundred grammes cauline; this is called *mangocau-*

line. Zincocarbocauline, which is an ultramarine blue, is obtained by introducing forty grammes chloride zinc and twenty-five grammes carbonate soda to five hundred grammes cauline.

NOTES.

Extensive excavations near Waldorf, in the neighborhood of Bonn, Germany, have brought to light the site of an old town believed to be of Roman origin, but the extent of which is yet quite unknown. The remains of a large Roman villa were discovered in the vicinity, situated a little below the site of an extinct volcano—a circumstance going to show that at the time of the Roman occupation the volcanoes of the Rhine had ceased to be dangerous.

James Clerk Maxwell, the distinguished Professor of Experimental Physics at the University of Cambridge, and the author of numerous works on physics, died at Cambridge, November 5, 1879, at the early age of forty-eight years.

A case of serious injury to the eyes, by the use of chloral, is given in a late number of the "Medical Record," on the authority of Dr. G. H. Felton, of Haverhill, Massachusetts. The Doctor writes that the drug was administered for a few days only, and apparently in the usual small doses. It caused severe pain in the eyes, obliged retirement to a darkened room for several days, and left a condition of weakness that has persisted for two years, and that still necessitates the occasional use of colored glasses.

By the death of Dr. Karl Friedrich Mohr, of Bonn, the science of chemistry has lost a worker whose valuable labors have extended over half a century. He was born in Coblenz, in November, 1806, and will be best remembered by the "Lehrbuch der chemisch-analytische Tetrirmethode," which appeared in 1855 and 1856. His published papers are mainly those devoted to meteorology and those bearing on volumetric analysis. Among the various subjects treated by him are ground-ice, ozone, St. Elmo's fire, lightning-conductors, hail, and rain. His various papers on chemical analysis extend over a period of fifty years.

The Brussels International Congress for Commercial Geography passed, among others, the following resolutions: "1. The Congress is of opinion that, in the interest of all nations, it is desirable that one or more lines of railway should connect the coasts of Africa with its interior. 2. Complete freedom of trade should reign there. 3. In the expectation of a complete abolition of custom-houses, it is desirable that as many commercial treaties as possible should be concluded. It is particularly necessary that a treaty of this kind should be preliminarily entered into between Belgium and Holland. 4. The Congress expresses the wish that everywhere instruction in history should be separate from that in geography."

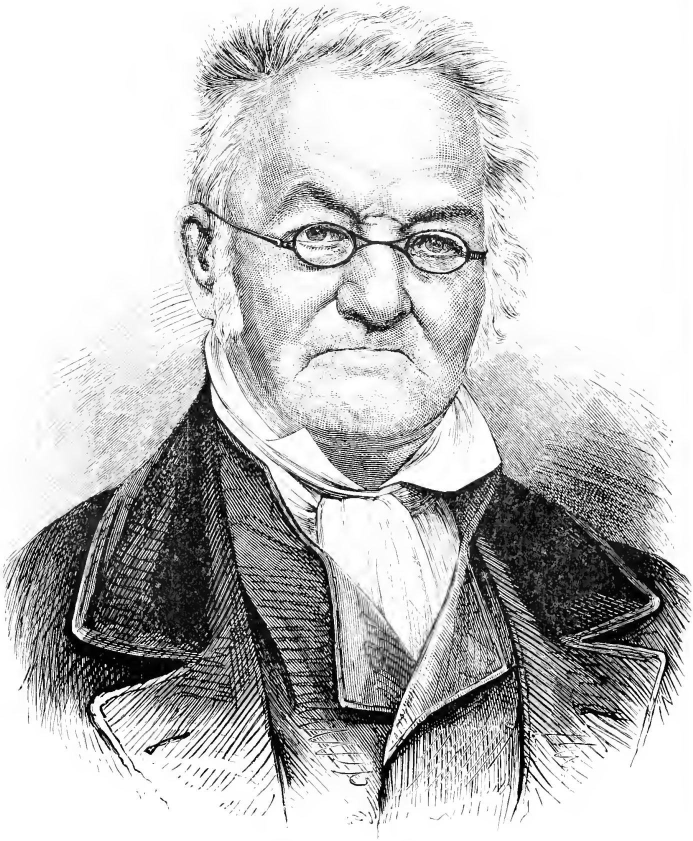
Died September 13, 1879, William W. Saunders, F. R. S., F. L. S., etc., of London. He was chiefly interested in natural history pursuits, giving special attention to botany and entomology, and was three times elected President of the Entomological Society of London. His natural history collections were extensive, and especially his cabinet of insects, which at one time was considered the most complete in England.

Stellar's manatee, which is supposed to have become extinct in 1786, has until recently been represented in Europe by only a few bones preserved in the museum at St. Petersburg. During his recent voyage Professor Nordenskiöld obtained numerous remains of the animal in the neighborhood of Behring Strait.

The death is announced of Lady Lubbock, the wife of Sir John Lubbock, on October 30, 1879. Besides a warm interest in her husband's scientific pursuits, Lady Lubbock was herself an occasional contributor to scientific journals, and among others published several years ago a paper of much interest on the "Shell-Mounds of Denmark," which attracted wide attention.

The Council for the Royal Society has awarded, this year, the following medals: "The Copley medal to Professor Rudolph J. E. Clausius, of Bonn, for his well-known researches upon heat; the Davy medal to Mr. P. E. Lecoy de Boisbaudran, for his discovery of gallium; a Royal medal to Mr. William Henry Perkin, F. R. S., for his synthetical and other researches in organic chemistry; and a Royal medal to Professor Andrew Crombie Ramsay, F. R. S., for his long-continued and successful labors in geology and physical geography.

The Apennine Railway reaches its highest point at an elevation of 2,000 feet above sea-level; the Black Forest Railway ascends to 2,762 feet, the Semmering line to 2,892 feet, the Caucasus line to 3,168 feet. The St. Gothard Tunnel is 3,750 feet above sea-level; the railway across the Brenner reaches 4,443 feet; the Mont Cenis Railway ascends to 4,348 feet, the North Pacific line to 5,369 feet, the Central Pacific to 6,121 feet, and the Union Pacific to 8,167 feet. The highest is the line across the Andes, which reaches an elevation of 15,500 feet.



CARL RITTER.

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THE ASSOCIATION OF IDEAS.

By WILLIAM JAMES, M. D.,
ASSISTANT PROFESSOR OF PHYSIOLOGY IN HARVARD COLLEGE.

THE manner in which trains of imagery and consideration follow each other through our thinking, the restless flight of one idea before the next, the transitions our minds make between things wide as the poles asunder, transitions which at first sight startle us by their abruptness, but which, when scrutinized closely, often reveal intermediating links of thought of perfect naturalness and propriety—all this magical, imponderable streaming has from time immemorial excited the admiration of every living man whose attention happened to be caught by its omnipresent mystery. And it has furthermore challenged the race of philosophers to try to banish something of the mystery by formulating the process in somewhat simpler terms.

Two great philosophic efforts to this end have been made. The one is called the associationist philosophy of England, the other the Herbartian system of Germany. Professor Bain's books are generally regarded as the most successful expression of the first movement. Volkmann's "Psychology" is perhaps the most finished utterance of the last. These schools differ as to their theoretic basis (the one being ontological and the other phenomenal), but they agree in almost all besides; especially in the attempt to show how all the different kinds of mental activity (such as memory, judgment, reasoning, self-consciousness, desire, etc., etc., which were formerly classed as distinct and original "faculties") may be explained as *resultants* of the manner in which, by the working of two or three simple elementary laws of revival between images, these latter are grouped into certain characteristic forms.

In fact, the easiest way of describing the entire industry of these schools would be to say that they seek to explain the forms of consciousness by means of its materials.

Now, to another class of minds any such attempt seems so preposterously absurd that they pour out the child with the bath, and disdain even a modest ambition which should content itself with tracing out in the jungle of the mind a few of the trails by which its *materials* are brought together. As this article is born of the latter ambition, and as its author thinks he has succeeded in making the trails broader and smoother than previous writers have left them, it behooves him to defend himself and his purpose by a few preliminary words addressed to this class of critics. They are recruited mainly from the school of Hegel, but we find even as fertile and acute a writer as Lotze sharing their prejudices and negations in this respect.

The intuition they start from is that thought is not a sand-heap of juxtaposed images with associating links outside of them and between them. It is a unitary *continuum* of which the items, and the logical relations between the items, form alike integral parts, equally imbedded, equally essential, equally interdependent. *Any* relation may carry us from one item to another, and according as we follow one or the other relation we shall traverse the field of thought in this way or in that, have one train of images or its opposite. But all the relations are *logical*, are relations of *reason*. A thing may suggest its like, or its opposite, its genus or its species, its cause or its effect, its means or its purpose, its habitual neighbors in space or in time, its possibilities or its impossibilities, its changes or its resistance to change—in short, it *may* call up every consideration to which it can have a possible logical relevancy, and call up each in its turn. And the only summary formula that can be applied to all these infinite possibilities of transition is that, as transitions of Thought, they are all alike *acts of Reason*. This monotonous appeal to "Thought" with a capital T and Reason with a capital R is apt to irritate the ear of him bent on analysis, very much as the stereotyped "Allah is great" of the Mussulman irritates the ear of the scientific traveler. It is true enough, but sterile. And, when it interdicts discrimination and the search for secondary causes, it performs as obstructive a function as that of our dear old friend the dog in the manger.

For these so-called "transitions of Reason" are far from being all alike reasonable. If pure Thought runs all our trains, why should she run some so fast and some so slow, some through dull flats and some through gorgeous scenery, some to mountain-heights and jeweled mines, others through dismal swamps and darkness?—and run some off the track altogether, and into the wilderness of lunacy? Why do we spend years straining after a certain scientific or practical problem, but all in vain—Thought refusing to evoke the solution we desire? And why, some day, walking in the street with our attention miles away from that quest, does the answer saunter into our minds as carelessly as if it had never been called for—suggested, possibly, by the flowers on the bonnet of the lady in front of us, or possibly by nothing that we can discover? If Reason can give us relief then, why did she not do so earlier?

The truth must be admitted that pure Thought works under conditions imposed *ab extra*. The great law of habit itself—that twenty experiences make us recall a thing better than one, that long indulgence in error makes right thinking almost impossible—seems to have no essential foundation in reason. The business of pure Thought is with Truth—the number of experiences ought to have nothing to do with her hold of it; and she ought by right to be able to hug it all the closer, after years wasted out of its presence. Such arrangements seem quite fantastic and arbitrary, but nevertheless are part of the very bone and marrow of our minds. Reason is only one out of a thousand possibilities in the thinking of each of us. Who can count all the silly fancies, the grotesque suppositions, the utterly irrelevant reflections he makes in the course of a day? Who can swear that his prejudices and irrational beliefs constitute a less bulky part of his mental furniture than his clarified opinions? It is true that a presiding arbiter seems to sit aloft in the mind, and emphasize the better suggestions into permanence, while it ends by dropping out and leaving unrecorded the confusion. But this is all the difference. The *mode of genesis* of the worthy and the worthless seems the same. The laws of our actual thinking, of the *cogitatum*, must account alike for the bad and the good materials on which the arbiter has to decide, for wisdom and for folly. The laws of the arbiter, of the *cogitandum*, of what we *ought* to think, are to the former as the laws of ethics are to those of history. Who but an Hegelian historian ever pretended that reason in action was *per se* a sufficient explanation of the political changes in Europe?

There are, then, mechanical conditions on which Thought depends, and which, to say the least, determine the order in which is presented the content or material for her comparisons, selections, and decisions. It is a suggestive fact that Locke, and many more recent Continental psychologists, have found themselves obliged to invoke a mechanical process to account for the aberrations of Thought, the obstructive prepossessions, the frustrations of Reason. This they found in the law of habit, or what we now call Association by Contiguity. But it never occurred to these writers that a process which could go the length of actually producing some ideas and sequences in the mind might safely be trusted to produce others too; and that those habitual associations which further thought may come from the same mechanical source as those which hinder it. Hartley accordingly suggested habit as an all-sufficient explanation, but failed to dispose of the difficulty which comes in when we notice that in the *highest* flights of Reason habit does not seem the link between one item and the next. Rather are the transitions of genius distinguished by their express defiance of all that is habitual.

This led to the erection of other laws to supply the gaps in explanation left by the law of habit alone. No sensible man now considers the habit-philosophy of Hartley, Priestley, and James Mill to be adequate to its task. Professor Bain, reverting to Hume's standpoint, supplements the law of Contiguity by that of Similarity, and, in a subordinate degree, by that of Contrast. *All* the materials of thought, without conception, are in his psychology pushed or drawn before the footlights of consciousness by the working of these laws and by them alone.

Mr. Hodgson, ablest of recent (if not of all) English philosophers, supplements Bain's laws by an important principle, that of Interest.

And every one before whose consciousness, when falling asleep, trains of faces and other disconnected images are wont to pass, and who, moreover, after his attention has once been called to the subject, surprises vestiges of the same process at work during his waking hours, in the form of a sort of meteoric shower of random images, visual or verbal, which cross the main current of thought, but are so faint that they ordinarily arrest no attention and are forthwith forgotten *—every such person, I say, will plead for the admission of a principle of spontaneity or accidental arousal, along with the principles already mentioned.

In the pages that follow I accept all these laws save that of contrast; and that I do not reject, but simply ignore and disregard on the present occasion. I try to show how they all may follow from certain variations in a fundamental process of activity in the brain. In particular I reduce Contiguous and Similar Associations to one, by exhibiting their most pronounced forms as mere extremes of a common mode. But the reader is requested to remember that in thus trying to explain, by laws of matter, what ideas shall be presented to consciousness at any moment, I expressly repudiate the pretension to explain the form of consciousness itself. Consciousness, as I understand it, is always in the midst of the present aware of the past as that from which the present came; and, out of the materials which the present furnishes, she is always comparing one part with another, to select that which most fits her ends. These peculiarities of consciousness were referred to above, when it was spoken of as a "presiding arbiter." I am wholly unable to picture this strange discriminating industry, this bringing of things together in order to keep them apart, this setting of ends and choosing from equal possibilities, in terms of any physical process whatever. The laws of association to be treated of here might, for aught we can see, be true in a creature wholly devoid of memory or comparison. Each of his ideas would vanish in the act of awakening its successor; his mind (if such it

* See Maury's classic work, "Le Sommeil et les Rêves."

could be called) would be shut up to the punctiform instant; he would obey, without noticing, the current which swept him on; drift to his conclusions, but never know why; and act upon the suggestions of experience with a fatality which would be inwardly all the blinder in proportion as it was the more rational to outward semblance. I simply *assume* for his benefit the possession of a consciousness. I *beg* that much from the reader's liberality; and limit my ambition to showing (the consciousness being granted) with what objects it is at any given moment most likely to be filled.

The laws of motor habit in the lower centers of the nervous system are disputed by no one. A series of movements repeated in a certain order tend to unroll themselves with peculiar ease in that order for ever afterward. Number one awakens number two, and that awakens number three, and so on, till the last is produced. A habit of this kind once become inveterate, like the manipulations of certain trades, the balancings of the body in standing or walking, the varying pressure of the legs in response to the swayings of a horse's gait, may go on automatically while the mind concerns itself with far other affairs. And so it is with thoughts. Not only poems, but the multiplication-table, Greek verbs, and formulas of gibberish like "*ana, mana, mona, mike*," etc., cohere in the self-same order in which they have once been learned. If we have blundered once in a certain place, we are prone to repeat the mistake again. The higher and the lower nerve-centers, then, are subject to one and the same law; and the reason of the law must be in both cases the same. The fact that there are isolated tracts of conduction in all the centers, and that as we pass from below upward the different centers have in the main different characteristic functions, leads to the notion that each function, ideational or motor, is dependent on a certain tract localized somewhere, which tract when once excited may propagate the excitement to other outlying tracts. The reason for the law of habit would, then, seem to be that the propagation occurs easiest through those tracts of conduction which have been already most in use. Descartes and Locke hit upon this explanation, which modern science has not yet succeeded in improving. "Custom," says Locke, "settles habits of thinking in the understanding as well as of determining in the will, and of motions in the body; all which seem to be but trains of motion in the *animal spirits* (by this Locke meant identically what we understand by the words *neural process*), which, once set agoing, continue in the same steps they have been used to, which by often treading are worn into a smooth path, and the motion in it becomes easy and as it were natural."

Let us, then, *assume* as the basis of all our subsequent reasoning the following law: *When two brain tracts or processes have occurred together or in immediate succession, any one of them, on reoccurring, tends to propagate its excitement into the other.*

Now, as a matter of fact, things in the brain are much less simple than this. Every elementary tract or process has found itself at different times excited in conjunction with *many* other tracts or processes, and this by unavoidable outward causes. Which of these others it shall awaken now becomes a problem. Shall *b* or *c* be aroused next by the present *a?* We must make a further postulate, based, however, on the undeniable fact of *tension* in nerve-tissue, and the summation of excitements, each incomplete or latent in itself, into an open resultant; *b* rather than *c* will awake, if in addition to the vibrating tract *a* some other tract *d* is in a state of sub-excitement, and formerly was excited with *b* alone and not with *a*. In short, we may say:

The amount of activity at any given point in the brain-cortex is the sum of the tendencies of all other points to discharge into it, such tendencies being proportionate (1) *to the number of times the excitement of each other point may have coexisted with that of the point in question;* (2) *to the intensity of such excitements; and* (3) *to the absence of any rival locality or process functionally disconnected with the first point, into which the discharges might be diverted.*

Expressing the fundamental law in this most complicated way leads to the greatest ultimate simplification. This will now be seen; but the reader will bear in mind that our limits only allow us to treat of spontaneous trains of thought and ideation, such as occur in reverie or musing. The case of voluntary thinking toward a certain end must be postponed to another opportunity.

Take, to fix our ideas, the two verses from "Locksley Hall":

> "I, the heir of all *the ages* in the foremost files of time,"

and—

> "For I doubt not through *the ages* one increasing purpose runs."

Why is it that when we recite from memory one of these lines and get as far as *the ages* that portion of the *other* line which follows, and, so to speak, sprouts out of *the ages*, does not also sprout out of our memory, and confuse the sense of our words? Simply because the word that follows *the ages* has its brain-process awakened not simply by the brain-process of *the ages* alone, but by it *plus* the brain-processes of all the words preceding *the ages*. The word *ages* at its moment of strongest activity would, *per se*, indifferently discharge into either "in" or "one." So would the previous words (whose tension is momentarily much less strong than that of *ages*) each of them indifferently discharge into either of a large number of other words with which they have been at different times combined. But when the processes of "So I doubt not through the ages" simultaneously vibrate in the brain, the strongest line of discharge will be that which they all alike tend to take. "One" and not "in" or any other word will be the next to awaken, for its brain-process has previously vibrated in unison not only with that of *ages*, but with that of all those other words whose activity is just dying away.

In case of some one of these preceding words—"heir," for example —having an intensely strong association with some brain-tracts entirely disjoined in experience from the poem of "Locksley Hall"—in case the reciter, for instance, was tremulously awaiting the opening of a will which might make him a millionaire or leave him penniless—it is probable that the path of discharge through the words of the poem would be suddenly interrupted at the word "heir." His emotional interest in that word would be such that its own special associations would prevail over the combined ones of the other words. He would, as we say, be abruptly reminded of his personal situation, and the poem would lapse altogether from his thoughts.

The writer of these pages has every year to learn the names of a large number of students who sit in alphabetical order in a lecture-room. On meeting one in the street, early in the year, the face hardly ever recalls the name, but it may recall the place of its owner in the lecture-room, his neighbors' faces, and consequently his general alphabetical position; and then, usually as the common associate of all these combined data, the student's name surges up in my mind.

A father wishes to show to some guests the progress of his rather dull child in Kindergarten instruction. Holding the knife upright on the table, he says, "What do you call that, my boy?" "I calls it a *knife*, I does," is the sturdy reply, from which the child can not be induced to swerve by any alteration in the form of question, until the father, recollecting that in the Kindergarten a pencil was used, and not a knife, draws a long one from his pocket, holds it in the same way, and then gets the wished-for answer, "I calls it *vertical*." All the concomitants of the Kindergarten experience had to recombine their effect before the word "vertical" could be reawakened.

Professor Bain, in his chapters on Compound Association, has treated in a minute and exhaustive way of this type of mental sequence, and what he has done so well need not be here repeated.

The ideal working of the law of compound association, were it unmodified by any extraneous influence, would be such as to keep the mind in a perpetual treadmill of concrete reminiscences from which no detail could be omitted. Suppose, for example, we begin by thinking of a certain dinner-party. The only thing which all the components of the dinner-party could combine to recall would be the first concrete occurrence which ensued upon it. All the details of this occurrence could in turn only combine to awaken the next following occurrence and so on. If a, b, c, d, e, for instance, be the elementary nerve-tracts excited by the last act of the dinner-party, call this act A, and l, m, n, o, p be those of walking home through the frosty night, which we may call B, then the thought of A must awaken that of B, because a, b, c, d, e, will each and all discharge into l through the paths by which their original discharge took place. Similarly they will discharge into m, n, o, and p, and these latter tracts will each re-enforce the other's action because, in the experience B, they have already vibrated in unison. The lines in the diagram symbolize the summation of discharges into each of the components of B, and the consequent strength of the combination of influences by which B in its totality is awakened.

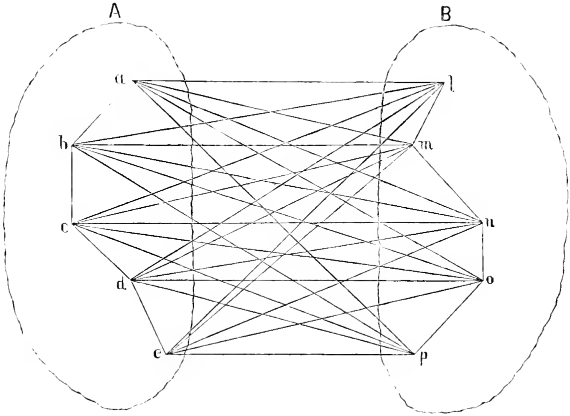


Fig. 1

Hamilton first used the word "redintegration" to designate all association. Such processes as we have just described might in an emphatic sense be termed redintegrations, for they would necessarily lead, if unobstructed, to the reinstatement in thought of the *entire* content of large trains of past experience. From this complete redintegration there could be no escape save through the irruption of some new and strong present impression of the senses or through the excessive tendency of some one of the elementary brain-tracts to discharge independently into an aberrant quarter of the brain. Such was the tendency of the word "heir" in the verse from "Locksley Hall," which was our first example. How such tendencies are constituted, we shall have soon to inquire with some care. Unless they are present, the panorama of the past, once opened, must unroll itself with fatal literality to the end, unless some outward sound, sight, or touch divert the current of thought.

I prefer to discard the word "redintegration" altogether, and to give to this unobstructed process the name of Complete Association by Contiguity. Whether it ever occurs in this absolutely complete form is doubtful. We all immediately recognize, however, that in some minds there is a much greater tendency than in others for the flow of thought to take this form. Those insufferably garrulous old women, those dry and fanciless beings who spare you no detail, however petty, of the facts they are recounting, and upon the thread of whose narrative all the irrelevant items cluster as pertinaciously as the essential ones, the slaves of literal fact, the stumblers over the smallest abrupt step in thought, are figures known to all of us. Comic literature has made her profit out of them. Juliet's nurse is a classical example. George Eliot's village characters and some of Dickens's minor personages supply excellent instances.

Perhaps as successful a rendering as any of this mental type is the character of Miss Bates in Miss Austen's "Emma." Hear how she redintegrates: "'But where could *you* hear it?' cried Miss Bates. 'Where could you possibly hear it, Mr. Knightley? For it is not five minutes since I received Mrs. Cole's note—no, it can not be more than five—or at least ten—for I had got my bonnet and spencer on, just ready to come out—I was only gone down to speak to Patty again about the pork—Jane was standing in the passage—were not you, Jane?—for my mother was so afraid that we had not any salting-pan large enough. So I said I would go down and see, and Jane said: "Shall I go down instead? for I think you have a little cold, and Patty has been washing the kitchen." "Oh, my dear," said I—well, and just then came the note. A Miss Hawkins—that's all I know—a Miss Hawkins, of Bath. But, Mr. Knightley, how could you possibly have heard it? for the very moment Mr. Cole told Mrs. Cole of it, she sat down and wrote to me. A Miss Hawkins—'"

But in every one of us there are moments when this complete reproduction of all the items of a past experience occurs. What are those moments? They are moments of emotional recall of the past as something which once was, but is gone for ever—moments, the interest of which consists in the feeling that our self was once other than it now is. When this is the case, any detail, however minute, which will make the past picture more complete, will also have its effect in swelling that total contrast between *now* and *then* which forms the central interest of our contemplation.

This case helps us to understand why it is that the ordinary spontaneous flow of our ideas does not follow the law of "complete" Association by Contiguity. In no revival of a past experience are all the items of our thought equally and impartially operative in determining what the next thought shall be. Always some ingredient is prepotent over the rest. Its special suggestions or associations in this case will often be different from those which it has in common with the whole group of items; and its tendency to awaken these outlying associates will deflect the path of our reverie. Just as in the original sensible experience our attention focalized itself upon a few of the impressions of the scene before us, so here in the reproduced representation of those impressions the same partiality is shown, and some items emphasized above the rest. What these items shall be is, in most cases of spontaneous reverie, hard to determine beforehand. In subjective terms we say that the prepotent items are those which appeal most to our *interest.*

Expressed in brain-terms, the law of interest will be: *some one brain-process is always prepotent above its concomitants in arousing action elsewhere.*

"Two processes," says Mr. Hodgson,* "are constantly going on in redintegration. The one a process of corrosion, melting, decay; the other a process of renewing, arising, becoming. . . . No object of representation remains long before consciousness in the same state, but fades, decays, and becomes indistinct. Those parts of the object, however, which possess an interest, that is, those which are attended by a representation of pleasure or pain, resist this tendency to gradual decay of the whole object. . . . This inequality in the object—some parts, the uninteresting, submitting to decay; others, the interesting parts, resisting it—when it has continued for a certain time, ends in becoming a new object." Only where the interest is diffused equally over all the parts (as in the emotional memory just referred to, where, as all *past,* they all interest us alike) is this law departed from. It will be least obeyed by those minds which have the smallest variety and intensity of interests—those who, by the general flatness and poverty of their æsthetic nature, are kept for ever rotating among the literal sequences of their local and personal history.

Most of us, however, are better organized than this, and our musings pursue an erratic course, swerving continually into a new direction traced out by the shifting play of interest as it irradiates always some partial item in each complex representation that is evoked. Thus it commonly comes about that we find ourselves thinking at two nearly adjacent moments of things separated by the whole diameter of space and time. Not till we carefully recall each step of our cogitation do we see how naturally we came by Hodgson's law to pass from one to the other. Thus, for instance, after looking at my clock just now, I found myself thinking of Senator Bayard's recent resolution about our legal-tender notes. The clock called up the image of the man who had repaired its gong. He suggested the jeweler's shop where I had last seen him; that shop, some shirt-studs which I had bought there; they, the value of gold and its recent decline; the latter, the equal value of greenbacks, and this naturally the question of how long they were to last, and of the Bayard proposition. Each of these images offered various points of interest. Those which formed the turning-points of my thought are easily assigned. The gong was momentarily the most interesting part of the clock, because, from having begun with a beautiful tone, it had become discordant and aroused disappointment and perplexity. But for this, the clock might have suggested the friend who gave it to me, or any one of a thousand circumstances connected with it. The jeweler's shop suggested the studs,

* "Time and Space," p. 266.

because they alone of all its contents were tinged with the egoistic interest of possession. This interest in the studs, their value, made me single out the material as its chief source, etc., to the end. Every reader who will arrest himself at any moment and say, "How came I to be thinking of just this?" will be sure to trace a train of representations linked together by lines of contiguity and points of interest inextricably combined. This is the ordinary process of the association of ideas as it spontaneously goes on in average minds. We may call it Partial or *Mixed Association.*

Another example of it is given by Hobbes in a passage which has been quoted so often as to be classical: "In a discourse of our present civil war, what could seem more impertinent than to ask (as one did) what was the value of a Roman penny? Yet the coherence to me was manifest enough. For the thought of the war introduced the thought of the delivering up the King to his enemies; the thought of that brought in the thought of the delivering up of Christ; and that again the thought of the thirty pence, which was the price of that treason: and thence easily followed that malicious question; and all this in a moment of time; for thought is quick."

Can we determine now when a certain portion of the going thought has, by dint of its interest, become so prepotent as to make its own exclusive associates the dominant features of the coming thought—can we, I say, determine *which* of its own associates shall be evoked? For they are many. As Hodgson says: "The interesting parts of the decaying object are free to combine again with any objects or parts of objects with which at any time they have been combined before. All the former combinations of these parts may come back into consciousness; one must; but which will?" Mr. Hodgson replies: "There can be but one answer: that which has been most *habitually* combined with them before. This new object begins at once to form itself in consciousness, and to group its parts round the part still remaining from the former object; part after part comes out and arranges itself in its old position; but scarcely has the process begun, when the original law of interest begins to operate on this new formation, seizes on the interesting parts and impresses them on the attention to the exclusion of the rest, and the whole process is repeated again with endless variety. I venture to propose this as a complete and true account of the whole process of redintegration."

In restricting the discharge from the interesting item into that channel which is simply most *habitual* in the sense of most frequent, Hodgson's account is assuredly imperfect. An image by no means always revives its most frequent associate, although frequency is certainly one of the most potent determinants of revival. If I abruptly utter the word *swallow*, the reader, if by habit an ornithologist, will think of a bird; if a physiologist or a medical specialist in throat-diseases, he will think of deglutition. If I say *date*, he will, if a fruit-merchant or an Arabian traveler, think of the produce of the palm ; if an habitual student of history, figures with A. D. or B. C. before them will rise in his mind. If I say *bed*, *bath*, *morning*, his own daily toilet will be invincibly suggested by the combined names of three of its habitual associates. But frequent lines of transition are often set at naught. The sight of C. Göring's "System der kritischen Philosophie" has most frequently awakened in me thoughts of the opinions therein propounded. The idea of suicide has never been connected with the volumes. But a moment since, as my eye fell upon them, suicide was the thought that flashed into my mind. Why? Because but yesterday I received a letter from Leipsic informing me that this philosopher's recent death by drowning was an act of self-destruction. Thoughts tend, then, to awaken their most recent as well as their most habitual associates. This is a matter of notorious experience, too notorious, in fact, to need illustration. If we have seen our friend this morning, the mention of his name now recalls the circumstances of that interview, rather than any more remote details concerning him. If Shakespeare's plays are mentioned, and we were last night reading "Richard II.," vestiges of that play rather than of "Hamlet" or "Othello" float through our mind. Excitement of peculiar tracts, or peculiar modes of general excitement in the brain leave a sort of tenderness or exalted sensibility behind them which takes days to die away. As long as it lasts, those tracts or those modes are liable to have their activities awakened by causes which at other times might leave them in repose. Hence, *recency* in experience is a prime factor in determining revival in thought.

Vividness in an original experience may also have the same effect as habit or recency in bringing about likelihood of revival. If we have once witnessed an execution, any subsequent conversation or reading about capital punishment will almost certainly suggest images of that particular scene. Thus it is that events lived through only once, and in youth, may come in after-years, by reason of their exciting quality or emotional intensity, to serve as types or instances used by our mind to illustrate any and every occurring topic whose interest is most remotely pertinent to theirs. If a man in his boyhood once talked with Napoleon, any mention of great men or historical events, battles or thrones, or the whirligig of fortune, or islands in the ocean, will be apt to draw to his lips the incidents of that one memorable interview. If the word *tooth* now suddenly appears on the page before the reader's eye, there are fifty chances out of a hundred that, if he gives it time to awaken any image, it will be an image of some operation of dentistry in which he has been the sufferer. Daily he has touched his teeth and masticated with them ; this very morning he brushed them, chewed his breakfast and picked them ; but the rarer and remoter associations arise more promptly because they were so much more intense.

A fourth factor in tracing the course of reproduction is *congruity in emotional tone* between the reproduced idea and our mood. The same objects do not recall the same associates when we are cheerful as when we are melancholy. Nothing, in fact, is more striking than our utter inability to keep up trains of joyous imagery when we are depressed in spirits. Storm, darkness, war, images of disease, poverty, and perishing afflict unremittingly the imaginations of melancholiacs. And those of sanguine temperament, when their spirits are high, find it equally impossible to give any permanence to evil forebodings or to gloomy thoughts in general. In an instant the train of association dances off to flowers and sunshine, and images of spring and hope. The records of Arctic or African travel perused in one mood awaken no thoughts but those of horror at the malignity of Nature; read at another time they suggest only enthusiastic reflections on the indomitable power and pluck of man. Few novels so overflow with joyous animal spirits as "The Three Guardsmen" of Dumas. Yet it may awaken in the mind of a reader depressed with sea-sickness (as the writer can personally testify) a most dismal and woful consciousness of the cruelty and carnage which heroes like Athos, Porthos, and Aramis make themselves guilty of.

Habit, recency, vividness, and emotional congruity are, then, all reasons why one representation rather than another should be awakened by the interesting portion of a departing thought. We may say with truth that in the majority of cases the coming representation will have been either habitual, recent, or vivid, and will be congruous. If all these qualities unite in any one absent associate, we may predict almost infallibly that that associate of the going thought will form an important ingredient in the coming thought. In spite of the fact, however, that the succession of representations is thus redeemed from perfect indeterminism and limited to a few classes whose characteristic quality is fixed by the nature of our past experience, it must still be confessed that an immense number of terms in the linked chain of our representations fall outside of all assignable rule. To take the instance of the clock given on page 586. Why did the jeweler's shop suggest the shirt-studs rather than a chain which I had bought there more recently, which has cost more, and whose sentimental associations were much more interesting? Both chain and studs had excited brain-tracts simultaneously with the excitement of others by the general aspect of the shop. The only reason why the nerve-stream from the shop-tract switched off into the stud-tract rather than the chain-tract must be that the stud-tract happened at that moment to lie more open, either because of some accidental alteration in its nutrition or because the incipient sub-conscious tensions of the brain as a whole had so distributed their equilibrium that it was more unstable here than in the chain-tract. Any reader's introspection will easily furnish similar instances. It thus remains true that to a certain extent, even in those forms of ordinary Mixed Association which lie nearest to Pure Association by Contiguity, *which* associate of the interesting item shall emerge must be called largely a matter of accident—accident, that is, for our intelligence. No doubt it is determined by cerebral causes, but they are too subtile and shifting for our analysis.

In Partial or Mixed Association we have all along supposed that the interesting portion of the disappearing thought was of considerable extent, was sufficiently complex to constitute by itself a concrete object. Sir William Hamilton relates that after thinking of Ben Lomond he found himself thinking of the Prussian system of education, and discovered that the links of association were a German gentleman whom he had met on Ben Lomond, Germany, etc. The interesting part of Ben Lomond, the part operative in determining the train of his ideas was the complex image of a particular man. But now let us suppose that that selective agency of interested attention, which may convert in the way we have seen complete contiguous association into partial association—let us suppose that it refines itself still further and accentuates a portion of the passing thought, so small as to be no longer the image of a concrete thing, but only of an abstract quality or property. Let us, moreover, suppose that the part thus accentuated persists in consciousness (or, in cerebral terms, has its brain-process excited) after the other portions of the thought have faded. This small surviving portion will then surround itself with its own associates after the fashion we have already seen, and the relation between the new thought and the faded one will be a *relation of similarity.* The pair of thoughts will form an instance of what is called "Association by Similarity." To make this perfectly plain we must understand exactly what constitutes similarity between two things. The moon is similar to a gas-jet, it is also similar to a foot-ball; but a gas-jet and a foot-ball are not similar to each other. When we affirm the similarity of two things, we should always say *in what respect it obtains.* Moon and gas-jet are similar in respect of luminosity, and nothing else; moon and foot-ball in respect of rotundity, and nothing else. Foot-ball and gas-jet are in no respect similar—that is, they possess no common point, no identical attribute. Objects are really identical with each other in that point with respect to which they are called similar. Similarity is partial identity. When the *same* attribute appears in two phenomena, though it be their only common property, the two phenomena are similar in so far forth. To return now to our associated representations. If the thought of the moon is succeeded by the thought of a foot-ball, and that by the thought of one of Mr. Vanderbilt's railroads, it is because the attribute rotundity in the moon broke away from all the rest and surrounded itself with an entirely new set of companions—elasticity, leathery integument, swift mobility in obedience to human caprice, etc.; and because the last-named attribute in the foot-ball in turn broke away from its companions, and, itself persisting, surrounded itself with such new attributes as make up the notions of a "railroad king," of a rising and falling stock-market, and the like.

The gradual passage from Complete Contiguous to Similar Associ-

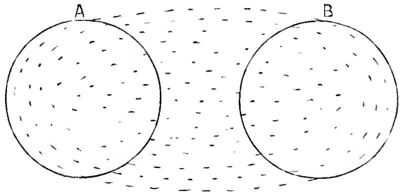


FIG. 2.

ation through what we have called Partial Association may be symbolized by diagrams. Fig. 2 is Pure Contiguous, Fig. 3 is Mixed, and Fig. 4 Similar, Association. A in each is the passing, B the coming thought. In "Contiguous," all parts of A are equally operative in

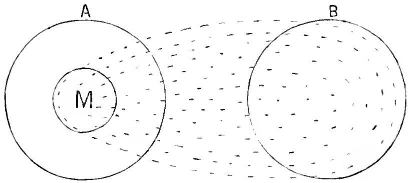


FIG. 3.

calling up B. In "Mixed," most parts of A are inert. The part M alone breaks out and awakens B. In "Similar," the focalized part M is much smaller than in the previous case, and after awakening its

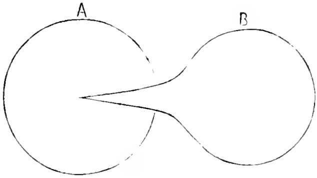


FIG. 4.

new set of associates, instead of fading out itself, it continues persistently active along with them, forming an identical part in the two ideas, and making these, *pro tanto*, resemble each other.

Why a single portion of the passing thought should break out from its concert with the rest and act, as we say, on its own hook, why the other parts should become inert, are mysteries which we can ascertain but not explain. Possibly a minuter insight into the laws of neural action will some day clear the matter up; possibly neural laws will not suffice, and we shall need to invoke a dynamic reaction of the form of consciousness upon its content. But into this we can not enter now.

Thus the difference between the three kinds of association reduces itself to a simple difference in the Amount of that portion of the nerve-tract supporting the going thought which is operative in calling up the thought which comes, but the *modus operandi* of this active part is the same, be it large or be it small.

The items constituting B waken in every instance because their nerve-tracts once were excited continuously with those of A or its operative part. This ultimate physiological law (*supra*, p. 583) is what *runs* the train. The direction of its course and the form of its transitions, whether contiguous or similar, are due to unknown regulative or determinative conditions which accomplish their effect by opening this switch and closing that, setting the engine sometimes at half speed, and coupling or uncoupling cars.

This last figure of speech affords itself an excellent instance of association by similarity. I was thinking of the deflections of the course of ideas. Now, from Hobbes's time downward English writers have been fond of speaking of the *train* of our representations. This word happened to stand out in the midst of my complex thought with peculiarly sharp accentuation, and to surround itself with numerous details of railroad imagery. Only such details became clear, however, as had their nerve-tracts besieged by a double set of influences—those from *train* on the one hand, and those from the *movement of thought* on the other. It may possibly be that the prepotency of the suggestions of the word *train* at this moment were due to the recent excitation of the railroad brain-tract by the instance chosen a few pages back of a railroad king playing foot-ball with the stock-market.

It is apparent from such an example how inextricably complex are all the contributory factors whose resultant is the line of our reverie. It would be folly in most cases to attempt to trace them out. From an instance like the above, where the pivot of the Similar Association was formed by a definite concrete word, *train*, to those where it is so subtile as utterly to elude our analysis, the passage is unbroken. We can form a series of examples. When Mr. Bagehot says that the mind of the savage, so far from being in a state of nature, is *tattooed* all over with monstrous superstitions, the case is very like the one we have just been considering. When Sir James Stephen compares our belief in the uniformity of nature, the congruity of the future with the past, to a man rowing one way and looking another, and steering his boat by keeping her stern in a line with an object behind him, the operative link becomes harder to dissect out. It becomes a real puzzle when the color pale-blue is said to have feminine, and blood-red masculine affinities. And if I hear a friend describe a certain family as having voices like *blotting-paper*, the image, though immediately felt to be apposite, baffles the utmost powers of analysis. The higher poets all use abrupt epithets, which are alike intimate and remote, and, as Emerson says, sweetly torment us with invitations to their inaccessible homes.

In these latter instances we must suppose that there is an identical portion in the similar ideas and that it is energetically operative, without, however, being sufficiently accentuated in consciousness to stand out *per se*, attract the attention to itself and be abstracted. We can not even by careful search see the bridge over which we passed from the heart of one representation to that of the next. In some brains, however, this mode of transition it extremely common. It would be one of the most important of physiological discoveries could we assign the mechanical or chemical difference which makes the thoughts of one brain cling close to Pure Contiguity, while those of another shoot about in all the lawless revelry of Similarity. Why in these latter brains action should tend to focalize itself in small spots, while in the others it fills patiently its broad bed, it seems impossible to guess. Whatever the difference may be, it is what separates the man of genius from the prosaic creature of habit and routine thinking. Professor Bain, more profusely and cogently than any one else, has illustrated the truth that the leading fact in what we call genius in every department of life is a high development of the power of Similar Association. I therefore refer the reader to his work on the "Study of Character," Chapter XV., and to Chapter II., sections 25 to 45, of the portion entitled "Intellect" of his treatise on "The Senses and the Intellect."

Into the study of voluntary trains of thought there is no space to enter. The student will find in Hodgson's "Theory of Practice," vol. i., pp. 394–400, the best account with which I am acquainted. Meanwhile he will no doubt admit that the promise with which this article set out has been fulfilled, and that the processes of spontaneous association have become already a little more intelligible to his mind.

DOLMENS IN JAPAN.

By EDWARD S. MORSE.

THOUGH a large amount of material has been collected and published regarding the megalithic structures of Europe, their classification is in a somewhat unsatisfactory condition.

The misery of the systematist has already made itself apparent in synonyms for a well-known class of monuments—namely, the dolmens. To make the matter more perplexing, structures of quite a different form, and possibly intended for a different purpose, are called by the same name.

A dolmen, generally speaking, consists of an arrangement of stones, few or many in number, supporting one or more stones in such a way as to inclose a cavity beneath. These supporting stones may form the four walls of a chamber, which may or may not be covered by a mound of earth. This chamber may or may not communicate outwardly by a long, narrow gallery (*allée couverte*). The mound may or may not have one or more rows of stones encircling it. And, finally, the stone structure may be on top of a mound of earth, instead of beneath it!

The simplest form of dolmen, if indeed it can be compared to the more elaborate structures bearing the same name, consists of several standing stones supporting one or more stones which rest upon them horizontally. If the roofing-stones rest with one end upon the ground, then it is called a demi-dolmen. A holed dolmen has one of the supporting stones (which generally forms one side of a square chamber) perforated. The demi-dolmens are not sufficiently specialized to establish any line of distribution. The holed dolmens are found in France and in India, and their curious resemblance has led many to believe in their common origin.

In the mound-covered dolmens a relationship is also seen between

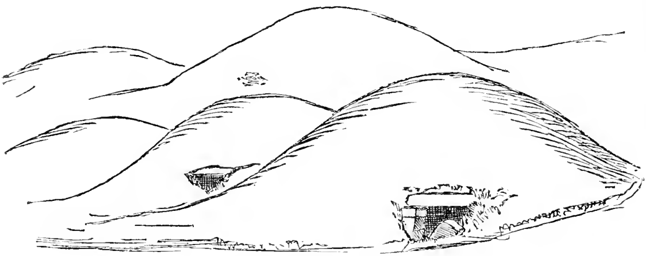


Fig. 1.—General Appearance of Dolmens.

those of Brittany and Scandinavia, in the passageway generally opening toward the south or east and never to the north.*

From the mass of observations brought together regarding the dolmens, Mr. Fergusson † has prepared a map showing their distribution in the Old World. From this map, dolmens are found to occur in the greatest number in France. They are also found in various parts of Great Britain, more abundantly on the eastern coast of Ireland,

* Lubbock, "Prehistoric Times," p. 124.

† Fergusson, "Rude Stone Monuments," 1872.

western coast of Wales, eastern coast of Scotland, southern portion of Sweden, and in Denmark and Northern Germany; also on the coast of Spain, Portugal, Northern Africa and the western portion of India. Mr. Fergusson, at the date of the publication of his book, asserts that the typical dolmen had not yet been found in America.

The occurrence in different parts of the world of a mound of earth containing a stone vault or chamber can not be looked upon as evidence of a community of origin, because such a structure seems to be a most natural form for the purposes of burial. The same structures

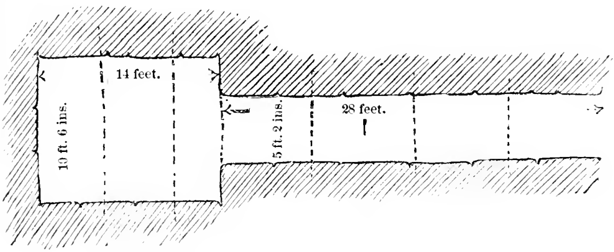


FIG. 2.—PLAN OF CHAMBER. The dotted lines show the roofing-stones.

are built to-day in many countries. It is only when it possesses some peculiar feature, like a perforation in one of its wall-stones, or a certain direction in which the passageway opens, that it suggests the idea that a common origin may be ascribed to those possessing these peculiarities.

In traveling across the southern part of Yeso last year, and also in a journey overland from the northern part of Japan to Tokio, I scanned the country carefully for mounds or monuments of any description. At the entrances of towns, one often sees two large mounds between which the road runs. Each mound is often surmounted by a large tree. Though these mounds are old, they are not prehistoric. With the exception of these, I saw nothing that would suggest a monument coming under the names of dolmen, menhir, etc.

There are many burial-mounds in Japan, such, for example, as the large one in Yamato, the grave of Jimmu Tenno, and others which are known to belong to historic periods. It is not improbable that the dolmens to be described belong to the same category.

It is difficult for one who has not traveled in Japan to realize the almost universal state of cultivation the country is under. Having a population of 33,000,000, largely given to agriculture, with an area not exceding 80,000 square miles, one may imagine how few tracts of uncultivated land are found. One is amazed at the sight of ranges of hills and mountains extending for miles, and all terraced to their very summits, for the cultivation of wheat and other products. The lower levels for miles are ditched and diked for rice-cultivation. This is specially marked along the coast bordering the Inland Sea, and along

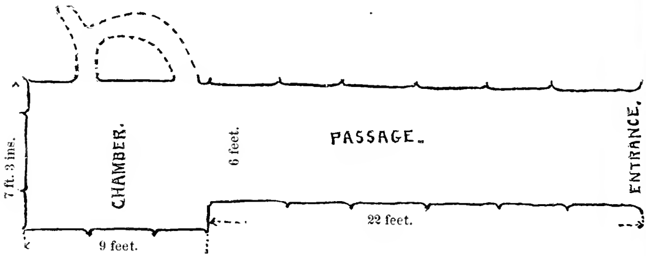


FIG. 3.—PLAN OF CHAMBER. Usual form.

the western coast of Kiushiu from Nagasaki round through Higo to Satsuma. This widespread cultivation has necessitated the leveling or other modifications of large tracts of country, and with this disturbance have probably disappeared many evidences of an ancient race. My attention was first called to the existence of some curious stone structures near Osaka, by Professor Yatabe, of the University of Tokio, who had received a letter from Mr. Ogawa, of the college at Osaka, with the request that I should examine them. This letter, accompanied by a few sketches, was published by Professor Yatabe in a Japanese periodical in Tokio.

On my return from an expedition to the southern portion of the empire, I visited Osaka with my assistant, Mr. Tanada, for the purpose of examining these structures. Mr. Ogawa and Mr. Amakusa, both teachers in the Osaka College, kindly accompanied me and rendered much assistance in the work of exploration. Our time was too limited to do more than make a hasty reconnaissance. We left Osaka early in the morning by *jinrikishas* (vehicles drawn by coolies), our way leading across extensive rice-fields, and our course directed to a range of low mountains about ten miles away. The country was as flat as a prairie, and had evidently been the floor of the sea at no remote geological period.

The dolmens are found in the villages Hattori Gawa and Kori Gawa, which lie at the base of a low chain of mountains. Having reached Hattori Gawa, we left our *jinrikishas*, and hunted up the head-man of the village who was to accompany us to the dolmens.

Providing ourselves with candles, we started up a rather steep road, and after a while diverged to the left, down through a tangled ravine —stopping at the door of a temple to examine an old pot which was brought out for our inspection, and which proved to be a piece of Bizen-ware, not very old. Shortly after, we came to a group of dolmens.

They are widely scattered in groups of several along the slopes of the mountains for a considerable distance; and their general appearance is not unlike the mounds of Upsala, Sweden, as represented in the frontispiece of Lubbock's "Prehistoric Times."

The structures consist of stone chambers covered by mounds of earth, communications with the chamber being by means of a long, straight, narrow passage—a typical *allée couverte*. The apices of the mounds are not so pointed as in the figure of Lubbock, and their slopes not so steep (see Fig. 1). They average fifteen to twenty feet in

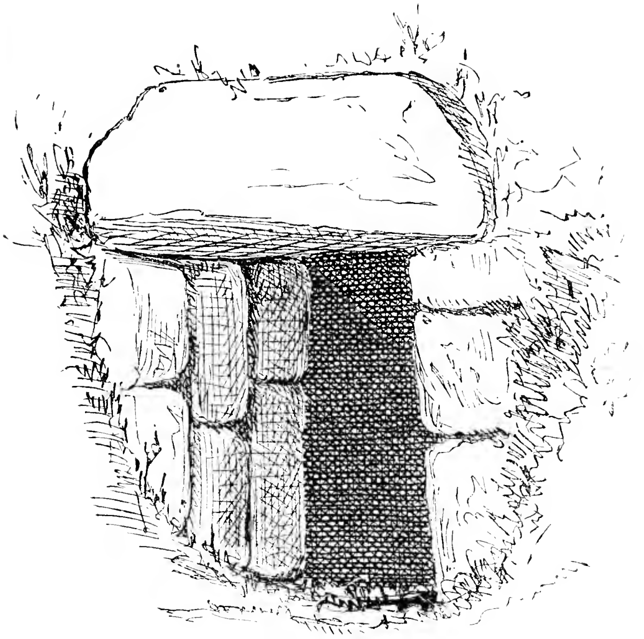


FIG. 4.—ENTRANCE TO CHAMBER.

height, and fifty to seventy-five feet in diameter. The entrances to most of the chambers are partially obstructed by dirt and stone which have tumbled from the sides and roof of the entrance. The stones composing the walls of the passageway and chamber were not large. In every case, however, the roofing-stones, both of the passageway and chamber, were of very large size. In some cases the entire roof of the chamber consisted of a single stone, and in one case four huge blocks formed the roof of a passageway twenty-eight feet long (see Fig. 2).

In every case, too, the stone which covered the passageway adjoining the chamber and forming part of its wall was of great size. The variation in the length of the passageways is due to their partial destruction. The other dimensions are quite uniform, as will be seen by comparing the following measurements of nine chambers, taken at random:

Length of Chamber.	Breadth of Chamber.	Height of Chamber.	Length of Passageway.	Breadth of Passageway.	Height of Passageway.
14·0	10·6	11·6	28	4·3	5·3
9·0	7·3	8·6	22	5·6	5·8
14·0	11·8	8·9	7	4·5	5·0
13·0	7·0	8·8	20	4·6	5·0
14·0	6·4	8·6	14	4·3	5·0
11·0	5·6	8·7	11	3·6	5·3
12·0	5·8	8·3	*	4·1	5·0
12·4	8·2	12·0	*	4·4	6·0
13·8	7·9	10·2	*	5·0	6·3

The plans vary but little—a single chamber, with the right wall flush with the right wall of the passageway, as in Fig. 3; or else the passageway entering the chamber on a median line, leaving a jog on each side, as in Fig. 2. Mr. Ogawa informed me that he had seen one with a small supplementary chamber leading from the end of the larger chamber.

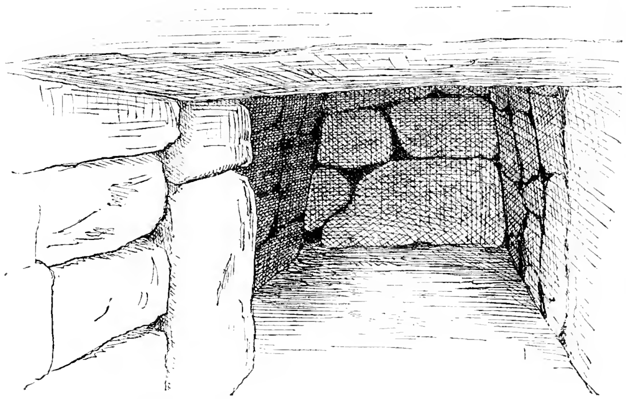


Fig. 5.—Appearance of Chamber from Passageway.

The passageway was nearly a foot narrower at the top than at the base, and in some cases was slightly narrower at the entrance.

In one case only were there signs that the chamber had been used

* Passageway partially destroyed. Measurement in feet and inches.

as a place of residence. A small opening between two of the wall-stones at the base of one of the chambers appeared blackened by fire. By removing the dirt and smaller stones which had tumbled down, I managed with some difficulty to crawl into an irregular flue which was blackened with smoke. This flue communicated with another smaller flue leading back into the chamber (see Fig. 2).

A rude sort of plaster was observed in some of the caves.

The walls of all the caves examined were carefully scrutinized to detect if possible signs of tool-marks or inscriptions, but nothing of the kind was observed. A careful search was made also for relics of some kind, but the floors were equally bare. Trenches were also dug down to the undisturbed soil, but no traces of pottery or implement of any description was found. This result is not surprising, when it is known that during the feudal days these chambers were often used as places of refuge for outlaws or political refugees, and during these times the earlier relics were probably removed or destroyed.

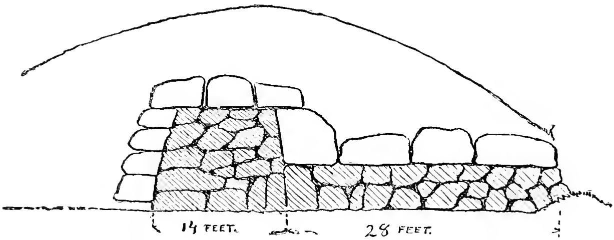


FIG. 6.—LONGITUDINAL SECTION OF DOLMEN, SHOWING CHAMBER AND PASSAGEWAY.

History records the fact that the governors of various provinces in which underground shelters occur ordered the closing of these places as a necessary measure.

No great antiquity can probably be assigned to these structures. That they are over a thousand years old there can be no doubt.* I am told by Japanese scholars that their early records call attention to these megalithic chambers existing in different parts of the country. Many of them have been destroyed, either for the purpose of securing the stone they contained for building materials, or to gain ground for cultivation.

In the vicinity of the dolmens and in the paths leading to them,

* In Fergusson's work, already alluded to, there is figured a dolmen of Uby, Scandinavia, page 311, and Antiquera, Spain, page 383, which resemble in many features the dolmens near Osaka. Jewitt also, in his work entitled "Grave-Mounds and their Contents," figures the dolmen of New Grange, Meath, Ireland, page 57, and the cairn of Howth, Ireland, page 58, which again recall similar features to those of the dolmens described in this article. In the cairn of Howth the passageway is twenty-seven feet long.

fragments of a hard, blue, unglazed pottery were found; and these fragments are identical with vessels dug up in various parts of the empire, which are regarded by Japanese archæologists as being of Corean origin, from nine to twelve hundred years old.

At the same meeting of the Boston Society of Natural History in which I communicated the results embodied in this paper, Professor F. W. Putnam announced the discovery of chambered mounds in

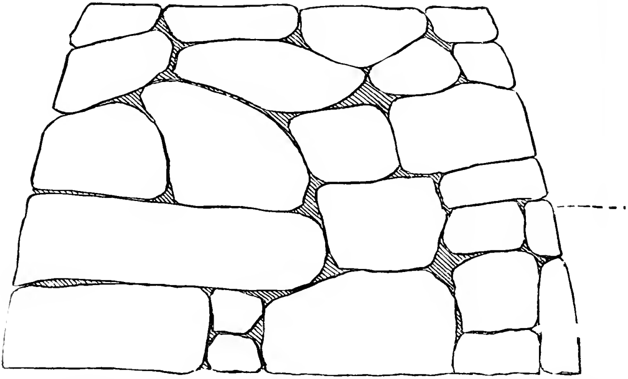


Fig. 7.—Showing Arrangement of Stones in Side-wall of Chamber. Length, 14 feet; height, 11 feet 6 inches. The dotted line to the right shows roof of passageway.

America, and communicated the following, which is taken from advance sheets of the "Proceedings" of that Society:

These chambered mounds are situated in the eastern part of Clay County, Missouri, and form a large group on both sides of the Missouri River. The chambers are, in the three opened by Mr. Curtiss, about eight feet square, and from four and a half to five feet high, each chamber having a passageway several feet in length and two in width, leading from the southern side, and opening on the edge of the mound formed by covering the chamber and passageway with earth. The walls of the chambered passages were about two feet thick, vertical, and well made of stones which were evenly laid, without clay or mortar of any kind. The top of one of the chambers had a covering of large, flat rocks, but the others seem to have been closed over with wood. The chambers were filled with clay which had been burned, and appeared as if it had fallen in from above. The inside walls of the chambers also showed signs of fire. Under the burned clay, in each chamber, were found the remains of several human skeletons, all of which had been burned to such an extent as to leave but small fragments of the bones, which were mixed with the ashes and charcoal. Mr. Curtiss thought that in one chamber he found the remains of five skeletons and in another thirteen. With these skeletons there were a few flint implements and minute fragments of vessels of clay.

A large mound near the chambered mounds was also opened, and in this no chambers were found. Neither had the bodies been burned. This mound proved remarkably rich in large flint implements, and also contained well-made pottery, and a peculiar "gorget" of red stone. The connection of the people who placed the ashes of their dead in the stone chambers with those who buried their dead in the earth-mounds is, of course, yet to be determined.

THE STUDY OF POLITICAL ECONOMY.*

By HENRY GEORGE.

I TAKE it that these lectures are intended to be more suggestive than didactic, and in what I shall have to say to you my object will be merely to induce you to think for yourselves. I shall not attempt to outline the laws of political economy, nor even, where my own views are strong and definite, to touch upon unsettled questions. But I want to show you, if I can, the simplicity and certainty of a science too generally regarded as complex and indeterminate, to point out the ease with which it may be studied, and to suggest reasons which make that study worthy of your attention.

Of the importance of the questions with which political economy deals it is hardly necessary to speak. The science which investigates the laws of the production and distribution of wealth concerns itself with matters which among us occupy more than nine tenths of human effort, and perhaps nine tenths of human thought. In its province are included all that relates to the wages of labor and the earnings of capital; all regulations of trade; all questions of currency and finance; all taxes and public disbursements—in short, everything that can in any way affect the amount of wealth which a community can secure, or the proportion in which that wealth will be distributed between individuals. Though not the science of government, it is essential to the science of government. Though it takes direct cognizance only of what are termed the selfish instincts, yet in doing so it includes the basis of all higher qualities. The laws which it aims to discover are the laws by virtue of which states wax rich and populous, or grow weak and decay; the laws upon which depend the comfort, happiness, and opportunities of our individual lives. And as the development of the nobler part of human nature is powerfully modified by material conditions, if it does not absolutely depend upon them, the laws sought for by political economy are the laws which at last control the mental and moral as well as the physical states of humanity.

Clearly, this is the science which of all sciences is of the first importance to us. Useful and sublime as are the sciences which open to

* Lecture before the students of the University of California, April, 1877.

us the vistas of Nature—which read for us the story of the deep past, or search out the laws of our physical or mental organization—what is their practical importance as compared with the science which deals with the conditions that alone make the cultivation of the others possible? Compare on this ground of practical utility the science of political economy with all others, and its preëminence almost suggests the reply of the Greek: "No, I can not play the fiddle; but I *can* tell you how to make of a little village a great and glorious city!"

How is it, then, it will naturally be asked, that a science so important is so little regarded? Our laws persistently violate its first and plainest principles, and that the ignorance thus exemplified is not confined to what are called the uneducated classes is shown by the debates in our legislative bodies, the decisions of our courts, the speeches of our party leaders, and the editorials of our newspapers. A century has elapsed since Adam Smith published his "Wealth of Nations," and sixty years since Ricardo enunciated his theory of rent. Yet not only has political economy received no substantial improvement since Ricardo, but, while thousands of new discoveries in other branches of human knowledge have been eagerly sized and generally utilized, and the most revolutionary conclusions of other sciences become part of the accepted data of thought, the truths taught by political economy seem to have made little real impression, and it is even now a matter of debate whether there is, or can be, such a science at all.

This can not be on account of the paucity of politico-economic literature. Enough books have been written on the subject within the last hundred years to fill a large library, while all of our great institutions of learning have some sort of a chair of political economy, and matters of intense public interest in which the principles of the science are directly involved are constantly being discussed.

It seems to me that the reasons why political economy is so little regarded are referable partly to the nature of the science itself and partly to the manner in which it has been cultivated.

In the first place, the very importance of the subjects with which political economy deals raises obstacles in its way. The discoveries of other sciences may challenge pernicious ideas, but the conclusions of political economy involve pecuniary interests, and thus thrill directly the sensitive pocket-nerve. For, as no social adjustment can exist without interesting a larger or smaller class in its maintenance, political economy at every point is apt to come in contact with some interest or other which regards it as the silversmiths of Ephesus did those who taught the uselessness of presenting shrines to Diana. Macaulay has well said that, if any large pecuniary interest were concerned in denying the attraction of gravitation, that most obvious of physical facts would not lack disputers. This is just the difficulty that has beset and still besets the progress of political economy. The man who is, or who imagines that he is, interested in the maintenance of a protective tariff, may accept all your professors choose to tell him about the composition of the sun or the evolution of species, but, no matter how clearly you demonstrate the wasteful inutility of hampering commerce, he will not be convinced. And so, to the man who expects to make money out of a railroad-subsidy, you will in vain try to prove that such devices to change the natural direction of labor and capital must cause more loss than gain. What, then, must be the opposition which inevitably meets a science that deals with tariffs and subsidies, with banking interests and bonded debts, with trades-unions and combinations of capital, with taxes and licenses and land-tenures! It is not ignorance alone that offers opposition, but ignorance backed by interest, and made fierce by passions.

Now, while the interests thus aroused furnish the incentive, the complexity of the phenomena with which political economy deals makes it comparatively easy to palm off on the unreasoning all sorts of absurdities as political economy. And, when all kinds of diverse opinions are thus promulgated under that name, it is but natural that the great number of people who depend on others to save themselves the trouble of thinking should look upon political economy as a field wherein any one may find what he pleases. But what is far worse than any amount of pretentious quackery is, that the science even as taught by the masters *is* in large measure disjointed and indeterminate. As laid down in the best text-books, political economy is like a shapely statue but half hewn from the rock—like a landscape, part of which stands out clear and distinct, but over the rest of which the mists still roll. This is a subject into which, in a lecture like this, I can not enter; but, that it is so, you may see for yourselves in the failure of political economy to give any clear and consistent answer to most important practical questions—such as the industrial depressions which are so marked a feature of modern times, and in confusions of thought which will be obvious to you if you carefully examine even the best treatises. Strength and subtilty have been wasted in intellectual hair-splitting and super-refinements, in verbal discussions and disputes, while the great high-roads have remained unexplored. And thus has been given to a simple and attractive science an air of repellent abstruseness and uncertainty.

And springing, as it seems to me, from the same fundamental cause, there has arisen an idea of political economy which has arrayed against it the feelings and prejudices of those who have most to gain by its cultivation. The name of political economy has been constantly invoked against every effort of the working classes to increase their wages or decrease their hours of labor. The impious doctrine always preached by oppressors to oppressed—the blasphemous dogma that the Creator has condemned one portion of his creatures to lives of toil and want, while he has intended another portion to enjoy "all the fruits of the earth and the fullness thereof"—has been preached to the working classes in the name of political economy, just as the "cursed-be-Ham" clergymen used to preach the divine sanction of slavery in the name of Christianity. In so far as the real turning questions of the day are concerned, political economy seems to be considered by most of its professors as a scientific justification of all that is, and by the convenient formula of supply and demand they seem to mean some method which Providence has of fixing the rate of wages so that it can never by any action of the employed be increased. Nor is it merely ignorant pretenders who thus degrade the name and terms of political economy. This character has been so firmly stamped upon the science itself as currently held and taught that not even men like John Stuart Mill have been able to emancipate themselves. Even the intellectually courageous have shrunk from laying stress upon principles which might threaten great vested interests; while others, less scrupulous, have exercised their ingenuity in eliminating from the science everything which could offend those interests. Take the best and most extensively circulated text-books. While they insist upon freedom for capital, while they justify on the ground of utility the selfish greed that seeks to pile fortune on fortune, and the niggard spirit that steels the heart to the wail of distress, what sign of substantial promise do they hold out to the workingman save that he should refrain from rearing children?

What can we expect when hands that should offer bread thus hold out a stone? Is it in human nature that the masses of men, vaguely but keenly conscious of the injustice of existing social conditions, feeling that they are somehow cramped and hurt, without knowing what cramps and hurts them, should welcome truth in this partial form; that they should take to a science which, as it is presented to them, seems but to justify injustice, to canonize selfishness by throwing around it the halo of utility, and to present Herod rather than Vincent de Paul as the typical benefactor of humanity? Is it to be wondered at that they should turn in their ignorance to the absurdities of protection and the crazy theories generally designated by the name of socialism?

I have lingered to inquire why political economy has in popular apprehension acquired the character of indefiniteness, abstruseness, and selfishness, merely that I may be the better able to convince you that none of these qualities properly belong to it. I want to draw you to its study by showing you how clear and simple and beneficent a science it is, or rather should be.

Although political economy deals with various and complicated phenomena, yet they are phenomena which may be resolved into simple elements, and which are but the manifestations of familiar principles. The premises from which it makes its deductions are truths of which we are all conscious and upon which in every-day life we constantly base our reasoning and our actions. Its processes, which consist chiefly in analysis, have a like certainty, although, as with all the causes of which it takes cognizance are at all times acting other causes, it can never predict exact results but only tendencies.

And, although in the study of political economy we can not use that potent method of experiment by artificially produced conditions which is so valuable in the physical sciences, yet, not only may we find, in the diversity of human society, experiments already worked out for us, but there is at our command a method analogous to that of the chemist, in what may be called mental experiment. You may separate, combine, or eliminate conditions in your own imagination, and test in this way the working of known principles. This, it seems to me, is the great tool of political economy. It is a method with which you must be familiar and doubtless use every day, though you may never have analyzed the process. Let me illustrate what I mean by something which has no reference to political economy.

When I was a boy I went down to the wharf with another boy to see the first iron steamship which had ever crossed the ocean to our port. Now, hearing of an iron steamship seemed to us then a good deal like hearing of a leaden kite or a wooden cooking-stove. But, we had not been long aboard of her, before my comrade said in a tone of contemptuous disgust: "Pooh! I see how it is. She's all lined with wood; that's the reason she floats." I could not controvert him for the moment, but I was not satisfied, and, sitting down on the wharf when he left me, I set to work trying mental experiments. If it was the wood inside of her that made her float, then the more wood the higher she would float; and, mentally, I loaded her up with wood. But, as I was familiar with the process of making boats out of blocks of wood, I at once saw that, instead of floating higher, she would sink deeper. Then, I mentally took all the wood out of her, as we dug out our wooden boats, and saw that thus lightened she would float higher still. Then, in imagination, I jammed a hole in her, and saw that the water would run in and she would sink, as did our wooden boats when ballasted with leaden keels. And, thus I saw, as clearly as though I could have actually made these experiments with the steamer, that it was not the wooden lining that made her float, but her hollowness, or, as I would now phrase it, her displacement of water.

Now, just such mental operations as these you doubtless perform every day, and in doing so you employ the method of imaginative experiment which is so useful in the investigations of political economy. You can, in this way, turn around in your mind a proposition or phenomenon and look on all sides of it, can isolate, analyze, recombine, or subject it to the action of a mental magnifying glass which will reveal incongruities as a *reductio ad absurdum*. Let me again illustrate:

Before I had ever read a line of political economy, I happened once to hear a long and well-put argument in favor of a protective tariff. Up to that time I had supposed that "protection to domestic industry" was a good thing ; not that I had ever thought out the matter, but that I had accepted this conclusion because I had heard many men whom I believed wiser than I say so. But this particular speaker had, so far as one of his audience was concerned, overshot his mark. His arguments set me thinking, just as when a boy my companion's solution of the iron-ship mystery had set me thinking. I said to myself : The effect of a tariff is to increase the cost of bringing goods from abroad. Now, if this benefits a country, then all difficulties, dangers, and impediments which increase the cost of bringing goods from abroad are likewise beneficial. If this theory be correct, then the city which is the hardest to get at has the most advantageous situation : pirates and shipwrecks contribute to national prosperity by raising the price of freight and the cost of insurance ; and improvements in navigation, in railroads and steamships, are injurious. Manifestly this is absurd.

And then I looked further. The speaker had dwelt on the folly of a great country like the United States exporting raw material and importing manufactured goods which might as well be made at home, and I asked myself, What is the motive which causes a people to export raw material and import manufactured goods? I found that it could be attributed to nothing else than the fact that they could in this way get the goods cheaper, that is, with less labor. I looked to transactions between individuals for parellels to this trade between nations, and found them in plenty—the farmer selling his wheat and buying flour; the grazier sending his wool to a market and bringing back cloth and blankets ; the tanner buying back leather in shoes, instead of making them himself. I saw, when I came to analyze them, that these exchanges between nations were precisely the same thing as exchanges between individuals ; that they were, in fact, nothing but exchanges between individuals of different nations ; that they were all prompted by the desire and led to the result of getting the greatest return for the least expenditure of labor ; that the social condition in which such exchanges did not take place was the naked barbarism of the Terra del Fuegians ; that just in proportion to the division of labor and the increase of trade were the increase of wealth and the progress of civilization. And so, following up, turning, analyzing, and testing all the protectionist arguments, I came to conclusions which I have ever since retained.

Now, just such mental operations as this are all that is required in the study of political economy. Nothing more is needed (but this *is* needed) than the habit of careful thought—the making sure of every step without jumping to conclusions. This habit of jumping to conclusions—of considering essentially different things as the same because of some superficial resemblance—is the source of the manifold and mischievous errors which political economy has to combat.

But I can probably, by a few examples, show you what I mean more easily than in any other way. Were I to put to you the child's question, "Which is heavier, a pound of lead or a pound of feathers?" you would doubtless be offended; and were I seriously to ask you, Which is the most valuable, a dollar's worth of gold or a dollar's worth of anything else? you might also feel that I had insulted your intelligence. Yet the belief that a dollar's worth of gold is more valuable than a dollar's worth of anything else is widespread and persistent. It has molded the policy of great nations, dictated treaties, marched armies, launched fleets, fought battles, constructed and enforced elaborate and vexatious systems of taxation, and sent men by thousands to jail and to the gallows. Certainly a large portion, probably a large majority, of the people of the United States—including many college graduates, members of what are styled the learned professions, senators, representatives, authors, and editors—seem to-day utterly unable to get it fully through their heads that a dollar's worth of anything else is as valuable as a dollar's worth of the precious metals, and are constantly reasoning, arguing, and legislating on the assumption that the community which exchanges gold for goods is suffering a loss, and that it is the part of wisdom, by preventing such exchange, to "keep money in the country." On this absurd assumption the revenue system of the United States is based to-day, and, if you will notice, you will find it cropping out of current discussions in all sorts of forms. Even here, where the precious metals form one of our staples, and for a long time constituted our only staple, you may see the power of the same notion. The anti-cooly clubs complain of the "drain of money to China," but never think of complaining of the drain of flour, wheat, quicksilver, or shrimps. And the leading journals of San Francisco, who hold themselves on an immeasurably higher intellectual level than the anti-cooly clubs, never, I think, let a week pass without congratulating their readers that we have ceased to import this or that article, and are thereby keeping so much money that we used to send abroad, or lamenting that we still send money away to pay for this or that which might be made here. Yet that we send away wine or wool, fruit or honey, is never thought of as a matter of lament, but quite the contrary. What is all this but the assumption that a dollar's worth of gold is worth more than a dollar's worth of anything else?

This fallacy is transparently absurd when we come to reduce it to a general proposition. But, nevertheless, the habit of jumping at conclusions, of which I have spoken, makes it seem very natural to people who do not stop to think. Money is our standard, or measure of values, in which we express all other values. When we speak of gaining wealth, we speak of "making money"; when we speak of losing wealth, we speak of "losing money"; when we speak of a rich man, we speak of him as possessed of much money, though as a matter of fact he may, and probably has, very little actual money. Then, again, as money is the common medium of exchange, in the process of getting things we want for things we are willing to dispose of, we generally first exchange the latter for money and then exchange the money for the things we want. And, as the number of people who want things of all sorts must manifestly be greater than the number of people who want the particular thing, whatever it may be that we have to exchange, any difficulty there may be in making our exchange will generally attend the first part of it; for, in exchanging anything for money, I must find some one who wants my particular thing, while in exchanging money for a commodity, any one who wants any commodity or service will be willing to take my money. Now, this habit of estimating wealth in money, and of speaking of gain or loss of wealth as gain or loss of money, and this habit of associating difficulties of exchange in individual cases with the difficulty of obtaining money, constantly lead people who do not think clearly to jump at the conclusion that money is more valuable than anything else. Yet the slightest consideration would show them that wealth never consists, but in very small part, of money; that the difficulty in individual exchanges has no reference to the relative value of money, and is eliminated when the exchanges of large numbers of individuals are concentrated or considered, and, in short, a dollar in money is worth no more than a dollar's worth of wheat or cloth; and that, instead of the exchange of money for other commodities being proof of a disadvantageous bargain, it is proof of an advantageous bargain, for, if we did not want the goods more than the money, we would not make the exchange.

Or, to take another example: In connection with the discussion of Chinese immigration, you have, doubtless, over and over again heard it contended that cheap labor, which would reduce the cost of production, is precisely equivalent to labor-saving machinery, and, as machinery operates to increase wealth, so would cheap labor. This conclusion is jumped at from the fact that cheap labor and labor-saving machinery similarly reduce the cost of production to the manufacturer. But, if, instead of jumping at this conclusion, we analyze the manner in which the reduction of cost is produced in each case, we shall see the fallacy. Labor-saving machinery reduces cost by increasing the productive power of labor; a reduction of wages reduces cost by reducing the share of the product which falls to the laborer. To the employer the effect may be the same; but, to the community, which includes both employers and employed, the effect is very different. In the one case there is increase in the general wealth; in the other there is merely a change in distribution—whatever one class gains another class necessarily losing. Hence the effect of cheap labor is necessarily very different from that of improved machinery.

And precisely similar to this fallacy is that which seems so natural to men of another class—that because the introduction of cheaper labor in any community *does*, in the present organization of society, tend to reduce the general level of wages, so does the importation of cheap goods. This, also—but I must leave you to analyze it for yourselves—springs from a confusion of thought which does not distinguish between the whole and the parts, between the distribution of wealth and the production of wealth.

Did time permit, I might go on, showing you by instance after instance how transparently fallacious are many current opinions—some, even, more widely held than any of which I have spoken—when tried by the simple tests which it is the province of political economy to apply. But my object is not to lead you to conclusions. All I wish to impress upon you is the real simplicity of what is generally deemed an abstruse science, and the exceeding ease with which it may be pursued. For the study of political economy you need no special knowledge, no extensive library, no costly laboratory. You do not even need text-books nor teachers, if you will but think for yourselves. All that you need is care in reducing complex phenomena to their elements, in distinguishing the essential from the accidental, and in applying the simple laws of human action with which you are familiar. Take nobody's opinion for granted; "try all things: hold fast that which is good." In this way, the opinions of others will help you by their suggestions, elucidations, and corrections; otherwise they will be to you but as words to a parrot.

If there were nothing more to be urged in favor of the study of political economy than the mental exercise it will give, it would still be worth your profoundest attention. The study which will teach men to think for themselves is the study of all studies most needed. Education is not the learning of facts; it is the development and training of mental powers. All this array of professors, all this paraphernalia of learning, can not educate a man. They can but help him to educate himself. Here you may obtain the tools; but they will be useful only to him who can use them. A monkey with a microscope, a mule packing a library, are fit emblems of the men—and, unfortunately, they are plenty—who pass through the whole educational machinery, and come out but learned fools, crammed with knowledge which they can not use—all the more pitiable, all the more contemptible, all the more in the way of real progress, because they pass, with themselves and others, as educated men.

But, while it seems to me that nothing can be more conducive to vigorous mental habits and intellectual self-reliance than the study which trains us to apply the analysis of thought to the every-day affairs of life, and to see in constantly changing phenomena the evidence of unchanging law; which leads us to distinguish the real from the apparent, and to mark, beneath the seething eddies of interest, passion, and prejudice, the great currents of our times—it is not on such incentives that I wish to dwell. There are motives as much higher than the thirst for knowledge, as that noble passion is higher than the lust for power or the greed of gold.

In its calculations the science of wealth takes little note of, nay, it often carefully excludes, the potent force of sympathy, and of those passions which lead men to toil, to struggle, even to die for the good of others. And yet it is these higher passions, these nobler impulses, that urge most strenuously to its study. The promise of political economy is not so much what it may do for you, as what it may enable you to do for others.

I trust you have felt the promptings of that highest of ambitions—the desire to be useful in your day and generation; the hope that in something, even though little, those who come after may be wiser, better, and happier that you have lived. Or, if you have never felt this, I trust the feeling is only latent, ready to spring forth when you see the need.

Gentlemen, if you but look, you will see the need! You are of the favored few, for the fact that you are here, students in a university of this character, bespeaks for you the happy accidents that fall only to the lot of the few, and you can not yet realize, as you may by and by realize, how the hard struggle which is the lot of so many may cramp and bind and distort—how it may dull the noblest faculties and chill the warmest impulses, and grind out of men the joy and poetry of life; how it may turn into the lepers of society those who should be its adornment, and transmute, into vermin to prey upon it and into wild beasts to fly at its throat, the brain and muscle that should go to its enrichment! These things may never yet have forced themselves on your attention; but still, if you will think of it, you can not fail to see enough want and wretchedness, even in our own country to-day, to move you to sadness and pity, to nerve you to high resolve; to arouse in you the sympathy that dares, and the indignation that burns to overthrow a wrong.

And seeing these things, would you fain do something to relieve distress, to eradicate ignorance, to extirpate vice? You must turn to political economy to know their causes, that you may lay the axe to the root of the evil tree. Else all your efforts will be in vain. Philanthropy, unguided by an intelligent apprehension of causes, may palliate or it may intensify, but it can not cure. If charity could eradicate want, if preaching could make men moral, if printing books and building schools could destroy ignorance, none of these things would be known to-day.

And there is the greater need that you make yourselves acquainted with the principles of political economy from the fact that, in the immediate future, questions which come within its province must assume a greater and greater importance. To act intelligently in the struggle in which you must take part—for positively or negatively each of you must carry his weight—you must know something of this science.

And this, I think, is clear to whoever considers the forces that are mustering—that the struggle to come will be fiercer and more momentous than the struggles that are past.

There is a comfortable belief prevalent among us that we have at last struck the trade-winds of time, and that by virtue of what we call progress all these evils will cure themselves. Do not accept this doctrine without examination. The history of the past does not countenance it, the signs of the present do not warrant it. Gentlemen, look at the tendencies of our time, and see if the earnest work of intelligent men be not needed.

Look even here. Can the thoughtful man view the development of our State with unmixed satisfaction? Do we not know that, under present conditions, just as that city over the bay grows in wealth and population, so will poverty deepen and vice increase; that just as the liveried carriages become more plentiful, so do the beggars; that just as the pleasant villas of wealth dot these slopes, so will rise up the noisome tenement-house in the city slums. I have watched the growth of San Francisco with joy and pride, and my imagination still dwells with delight upon the image of the great city of the future, the queen of all the vast Pacific—perhaps the greatest city of the world. Yet what is the gain? San Francisco of to-day, with her three hundred thousand people, is, for the classes who depend upon their labor, not so good a place as the San Francisco of sixty thousand; and when her three hundred thousand rises to a million, San Francisco, if present tendencies are unchanged, must present the same sickening sights which in the streets of New York shock the man from the open West.

This is the dark side of our boasted progress, the Nemesis that seems to follow with untiring tread. Where wealth most abounds, there poverty is deepest; where luxury is most profuse, the gauntest want jostles it. In cities which are the storehouses of nations, starvation annually claims its victims. Where the costliest churches rear the tallest spires toward heaven, there is needed a standing army of policemen; as we build new schools, we build new prisons; where the heaviest contributions are raised to send missionaries to the ends of the earth to preach the glad tidings of peace and good-will, there may be seen squalor and vice that would affright a heathen. In mills where the giant power of steam drives machinery that multiplies by hundreds and thousands the productive forces of man, there are working little children who ought to be at play or at school; where the mechanism of exchange has been perfected to the utmost, there thousands of men are vainly trying to exchange their labor for the necessaries of life!

Whence this dark shadow that thus attends that which we are used to call "material progress," that which our current philosophy teaches us to hope for and to work for? Here is the question of all questions for us. We must answer it or be destroyed, as preceding civilizations have been destroyed. For no chain is stronger than its weakest link, and our glorious statue with its head of gold and its shoulders of brass has as yet but feet of clay!

Political economy alone can give the answer. And, if you trace out, in the way I have tried to outline, the laws of the production and exchange of wealth, you will see the causes of social weakness and disease in enactments which selfishness has imposed on ignorance, and in maladjustments entirely within our own control.

And you will see the remedies. Not in wild dreams of red destruction nor weak projects for putting men in leading-strings to a brainless abstraction called the state, but in simple measures sanctioned by justice. You will see in light the great remedy, in freedom the great solvent. You will see that the true law of social life is the law of love, the law of liberty, the law of each for all and all for each; that the golden rule of morals is also the golden rule of the science of wealth; that the highest expressions of religious truth include the widest generalizations of political economy.

There will grow on you, as no moralizing could teach, a deepening realization of the brotherhood of man; there will come to you a firmer and firmer conviction of the fatherhood of God. If you have ever thoughtlessly accepted that worse than atheistic theory that want and wretchedness and brutalizing toil are ordered by the Creator, or, revolting from this idea, if you have ever felt that the only thing apparent in the ordering of the world was a blind and merciless fate careless of man's aspirations and heedless of his sufferings, these thoughts will pass from you as you see how much of all that is bad and all that is perplexing in our social conditions grows simply from our ignorance of law—as you come to realize how much better and happier men might make the life of man.

WARD'S NATURAL SCIENCE ESTABLISHMENT.

By Professor JOSEPH LEIDY.

A RECENT visit to Professor Henry A. Ward's "Natural Science Establishment" at Rochester, New York, led the writer to some reflections on the comparative value of a knowledge of natural history. In the prevailing systems of education, the subject is totally disregarded, or receives but trifling consideration. The classical languages and history, on the other hand, have always been taught, and are yet considered by the greater portion of the cultivated people as essential to a complete education, while the sciences have been treated as only of secondary importance. The information possessed by a country boy, gained by intelligent observation, of the birds or plants of his neighborhood, is viewed by the so-called educated community as insignificant in comparison with that of the college boy who can relate stories, from classical history, of persons who never existed and events that never occurred.

Considering the circumstance that all things, except what we make of them, are natural objects, it would seem that the first and main efforts of education, after acquiring sufficient language and arithmetic to express our ideas of qualities and numbers, would be to learn what the objects are. The child on learning to speak at once begins to ask about the things it sees, but unfortunately too often the parent and teacher are incapable of giving the desired information, and ordinarily it meets with so little satisfaction that finally the spirit of inquiry disappears. For most persons, after distinguishing the ordinary articles pertaining to the necessities and conveniences of life, the crudest generalities of knowledge appear to be sufficient. With them it seems to be enough to know that things are stones, metals, and dirt; weeds, flowers, and trees; bugs, animals, and men. Among the cultivated, one is considered the no less educated if he calls a worm a snake, or a caterpillar a nasty reptile; while he may run the risk of being called ignorant, or at least uneducated, if he can not translate a Latin text. Though quartz is the most abundant mineral substance of the land in which we live, yet perhaps not one in a hundred of an educated community knows a quartz-pebble from any other.

To the writer the sciences, including natural history, have appeared to be of the utmost importance to the welfare and happiness of mankind, and no other branches of knowledge can equal them in these relations.

To facilitate the study and to create a more general interest in natural history, museums of characteristic specimens should not only be connected with every college and other educational institutions, but there should be established in every considerable town a free public museum—not a mere show or place of amusement, a collection of curiosities and rare specimens, queer things, a two-headed calf, or a dried hand of a murderer, but a series of specimens, often of familiar objects, illustrative of the classes, orders, and other chief divisions of the mineral, vegetal, and animal kingdoms, together with those which illustrate geology and kindred subjects. A museum of this kind should further be supplied with specimens of all the natural productions of the vicinity, which may be collected from time to time by those who are, or may become, most interested in the study of natural history. Such a museum would not only be of the greatest service as a means of instruction, but would prove useful in a variety of ways to the community, and would also give additional interest to the visits of strangers to the locality.

Professor Ward's great establishment is intended to supply a complete series of illustrative specimens in all the departments of natural history for educational museums. The writer had repeatedly seen and admired collections of specimens from this establishment in colleges and other institutions, but it was only recently that he was induced to visit the former itself. It greatly exceeded his expectations, and surprised him by its extent as well as delighted him from the excellence and beauty of its collections. Many buildings were stored with admirably mounted and well-preserved vertebrates, snowy-white skeletons, a multitude of invertebrates, excellent models, fine collections of minerals, and characteristic series of rocks and fossils. Even in the great capitals of Europe nowhere did the writer see so great and excellent a stock from which to furnish museums; and it is in grateful appreciation of the able and zealous services of Professor Ward, in the interest of natural history, that the writer takes this opportunity of recommending his establishment to those who desire to obtain collections. In conclusion, to exemplify how much may be taught of whole groups or orders from a few specimens, the writer presents the following instance: He had in his possession a fragment of red coral, the material so much used for ornament. Notwithstanding much explanation, persons ordinarily appeared to him to be incredulous as to its animal nature. In viewing Professor Ward's collections, he espied among thousands of actual specimens a pair of beautiful models of the red coral, one representing the object of natural size covered with the soft flesh and exhibiting the tiny polyps; the other representing a magnified view, exhibiting a fragment of a stem with three polyps. These were purchased for one dollar each, and are now placed together with the natural coral fragment, and not only tell the whole story of the animal at a glance, but tell that of the whole order to which it belongs. Many such examples might be related, but one is enough.

It is this careful attention of Professor Ward to the scientific and educational import of his collections which has given his natural history establishment its high appreciation among the naturalists and the science teachers of our country.

THE FORCE BEHIND NATURE.

By WILLIAM B. CARPENTER, M. D., F. R. S.

SOME thirty years ago, I enjoyed opportunities of discussing with John Stuart Mill (whose younger brother had been for twelve months an inmate of my house) many questions of philosophy in which we both felt the deepest interest. Among these was the Doctrine of Causation set forth in his recently published "System of Logic": "We may define the cause of a phenomenon to be the antecedent, or the concurrence of antecedents, on which it is invariably and unconditionally consequent." I pointed out to my friend that, when this assemblage of conditions is analyzed, it is uniformly found resolvable into two categories, which may be distinguished as the *dynamical* and the *material;* the former supplying the *force* or *power* to which the change must be attributed, while the latter affords the *conditions* under which that power is exerted. Thus, I urged, when a man falls from a ladder *because* (as is commonly said) of the breaking of the rung on which his foot was resting, the real or *dynamical* cause of his fall is the force of gravity, or attraction of the earth, which pulls him to the ground when his foot is no longer supported; the loss of support being only the *material condition* or *collocation*, which allowed the force previously acting as *pressure* on the rung to produce the downward *motion* of the man who stood upon it.

To this Mr. Mill's reply was, that the distinction is one of metaphysics, not of logic. I ventured, however, to press on him that, to whichever department of philosophy this point is to be referred, it is one of fundamental importance; that, assuming experience as the basis of our knowledge, we recognize the downward tendency of every body heavier than air, by our sense of muscular tension in lifting it from the ground, or in resisting its descent toward the earth; and that our cognition of *force* through this form of sensation, being thus quite as immediate and direct as our cognition of *motion* through the visual sense, ought to be equally taken account of.

The promulgation, about the same time, of the doctrine of the "Correlation of the Physical Forces" by Professor (now Sir William) Grove, and the researches of Mr. Joule on the "Mechanical Equivalent of Heat," seemed to me to bring this view of *dynamical* causation into yet greater importance, by showing that what is true of that form of force which produces or resists mechanical (or what is now distinguished as *molar*) motion, may be legitimately extended to those other forms which are manifested in the *molecular* changes that express themselves in chemical action, or impress us with the sensations of heat, light, etc. Partaking of the general ignorance at that time prevalent in this country of the doctrine of "Conservation of Energy," already promulgated in Germany by Mayer and Helmholtz, I myself endeavored to carry Professor Grove's principle into the domain of biology, by showing that what physiologists had been accustomed to call vital force may be regarded as having the same "correlation" with the various forms of physical force as they have with each other.* And in the introduction to the fourth edition of my "Human Physiology" (published in 1853) I thus explicitly defined my position:

When this assemblage of antecedents is analyzed, it is uniformly found that they may be resolved into two categories, which may be distinguished as the *dy-*

* "On the Mutual Relations of the Vital and Physical Forces," in "Philosophical Transactions," 1850.

namical and the *material*, the former supplying the *force* or *power* to which the change must be attributed, while the latter afford the *conditions* under which that power is exerted. Thus, in a steam-engine we see the dynamical agency of heat made to produce mechanical power by the mode in which it is applied: first, to impart a mutual repulsion to the particles of water; and then, by means of that mutual repulsion, to give motion to the various solid parts of which the machine is composed. And thus, if asked what is the cause of the movement of the steam-engine, we distinguish in our reply between the *dynamical* condition supplied by the heat and the *material* condition (or assemblage of conditions) afforded by the "collocation" of the boiler, cylinder, piston, valves, etc. . . . In like manner, if we inquire into the cause of the germination of a seed—which has been brought to the surface of the earth after remaining dormant through having been buried deep beneath the soil for (it may be) thousands of years—we are told that the phenomenon depends upon warmth, moisture, and oxygen; but out of these we single warmth as the *dynamical* condition, while the oxygen and the water, with the organized structure of the seed itself, and the organic compounds which are stored up in its substance, constitute the *material*.

The subsequent general recognition by the scientific world of the "correlation" between the forces of nature (under whatever form expressed) has thus given a breadth of foundation to the dynamical doctrine of causation which it previously lacked; and the doctrine, having been afterward formally developed by Professor Bain, was summarized by J. S. Mill, in the later editions of his "Logic," almost in the very terms in which I had originally propounded it to him in conversation, and had publicly expressed it in the extract just cited: "The chief practical conclusion drawn by Professor Bain, bearing on causation, is that we must distinguish, in the assemblage of conditions which constitutes the cause of a phenomenon, two elements: one, the presence of a force; the other, the collocation or position of objects which is required in order that the force may undergo the particular transmutation which constitutes the phenomenon."* Mr. Mill himself still preferred, however, to express the principle in terms of motion rather than in terms of force: "If the effect, or any part of the effect, to be accounted for consists in putting matter in motion, then any of the objects present which has lost motion has contributed to the effect; and this is the true meaning of the proposition that the cause is that one of the antecedents which exerts active force." As this mode of expressing the facts is sanctioned by high authorities at the present time, it may be well for me to explain more fully the basis of my original contention, that our cognition of *force* is quite as immediate and direct as our cognition of *motion*; in fact (as I think I shall be able to prove), even more fundamental, inasmuch as our cognition of matter itself is in great degree dependent upon it.

It has been recently well said that "all true science involves both the knowledge of nature and the knowledge of man; it includes the study of mind, as well as of matter. A philosopher may pursue either,

* "System of Logic," eighth edition, vol. i., p. 406.

but he can have no complete knowledge of what he investigates, without borrowing from the other department of investigation." * Many of the Nature-philosophers who affirm that we have no knowledge of anything but the matter and motion which lie within the range of "experience" show themselves very imperfectly acquainted with what "experience" really means; unhesitatingly ranking as actual objective facts their own mental interpretations of the sensory impressions they receive from external objects. Many metaphysicians, on the other hand, have reasoned as if our concern were with mental operations alone, and as if the abstractions in which they deal had an existence *per se*, without any relation to the phenomena of nature. But, among the ablest thinkers of the present time, there seems to be now a pretty general recognition of the necessity for the replacement of the abstract definitions of metaphysics—so far, at least, as they relate to the external world—by psychological expressions of the modes in which the human *ego* is affected by its changes. Thus the ordinary metaphysical definition of "matter" is that which possesses "extension." But, for this definition to convey any definite idea to our minds, we must know what "extension" means; and this, we are told, is the "occupation of space." Now, the conception of "space," in the opinion of most psychologists, is ordinarily derived from our interpretation of *visual* sensations; and yet these may be altogether deceptive. When we look at a window from a short distance, we can not tell by the use of our eyes alone whether the space included by its frame is void, or is occupied by a perfectly transparent and colorless glass. A glass globe is held up in front of it, and we can not tell by looking at it whether it is empty, or is filled with pure water or some other transparent colorless liquid. And we can take no cognizance by our vision of the atmosphere which surrounds us, unless its transparence is interfered with by mist or fog. Clearly, then, our visual sense can not *per se* furnish us with a satisfactory definition of matter.†

Now that we have got rid of the fiction of "imponderables," we might fall back on a definition of matter—in use before that fiction was invented—as that which possesses "ponderosity" or weight. But what is weight? The downward tendency, it may be replied, in virtue of which all unsupported bodies fall to the earth. But what is

* "Natural Theology of the Doctrine of the Forces." By Professor Benjamin Martin, of the University of the City of New York.

† According to Professor Bain, the conception of space is essentially based on the sense of muscular tension which, according to him, we experience in the ordinary movements of our eyes. But I am satisfied that this is physiologically erroneous. These movements are ordinarily guided, as Professor Alison long ago contended, and as Professor Helmholtz and I myself have since experimentally proved, by the visual, not by the muscular sense; and it is only when we put the muscles to an unusual strain—as when our visual axes converge on an object brought nearer and nearer to the eyes, or when we entirely exclude light from the retina—that we experience any sense of tension in their muscles.

this "tendency"? We might *see* any number of bodies falling to the ground, and might frame a correct law of their motion, without having the remotest conception of their possessing that downward *pressure* which we at once recognize when we take a lump of lead or iron into our hands; and it is obviously on our cognition of this pressure, that our idea of weight or ponderosity is based. Now, the instrumentality through which we take cognizance of it seems to me to be threefold: In the first place, we have the sense of simple pressure on the tactile surface—as when, the hand passively resting on a table, a weight is laid upon it. Secondly, we recognize it by the sense of *tension* which we experience when a weight is attached to a pendent limb, and which we refer to the muscles and ligaments which are thus put on the stretch; or when, the hand resting on the top of a cylinder of glass placed over an air-pump, the air is exhausted from beneath, so as to make us *feel* the downward "pressure of the atmosphere." In these two cases, the mind is the passive recipient of the sensory impressions. But, thirdly, when we determinately lift a weight or hold it suspended by our hands, we experience, in addition to the sense of pressure and the sense of tension, a *sense of effort*, which we recognize as an *immediate* revelation of consciousness, not referable to any physical impression, but of the same kind as that which we experience in a purely mental act, such as the fixation of the attention. And a little consideration will, I think, make it clear that it is on this "sense of effort" in resisting downward pressure that our cognition of weight is essentially based.

For, in the first place, the *continuance* of a moderate pressure on the cutaneous surface, like other sensory impressions that become habitual, soon ceases to affect us sensorially; for we cognosce rather the *changes* in the states of our sense-organs than the states themselves. Or, again, we may suffer under a temporary or permanent paralysis of the cutaneous sense, that may prevent our feeling the contact of the body we are lifting or supporting; and yet, recognizing its downward pressure in other ways, we can put our muscles into action to antagonize it. But, secondly, this paralysis may extend to the muscular sense, so that the feeling of muscular tension is wanting as well as that of contact-pressure; and yet none the less can a weight be lifted or sustained by a conscious effort, provided that the deficiency of the guiding sensations ordinarily derived from the muscle itself is supplied by the sight. A woman whose arm is sensorially but not motorially paralyzed can hold up her child as long as she looks at it, and a man affected with the like paralysis of his legs can stand and walk while looking at his feet. But, thirdly, since the *mental sense of effort* is experienced in every determinate exercise of our muscular power, and is, as all experience teaches, a necessary condition of that exercise; since, again, it is proportioned to the exertion we put forth, and continues as long as that exertion is sustained—it is in this, and not in the cutaneous or muscular impressions which are (so to speak) accidental, that (as it seems to me) we find the real basis of our cognition of the "ponderosity" of matter.

But "ponderosity" can not be considered an essential property of matter, being merely the "accident" of the earth's attraction for bodies lying within its range. This attraction varies with the distance of a body from the center of the earth; and a body occupying the common center of gravity of the earth and sun would be equally drawn toward both, and would consequently have no "weight." We must, therefore, seek a satisfactory definition of matter elsewhere; and we find the clew to it in the consideration that the sense of effort we experience in antagonizing the downward pressure of a body is but a particular case of our more general cognition of *resistance*. When we project our hand against a hard and fixed solid body, our consciousness of its resistance to our pressure is exactly that which we experience when we try to raise a weight that we have not strength to lift; while, if that solid be either yielding in its parts or movable as a whole, we measure its resistance, as in lifting a weight, by our sense of the effort necessary to overcome it. When we move our hand through a liquid, we are conscious of a resistance to its motion, which is greater or less according to the "viscosity" of the liquid. And, when we move our open hand through air at rest, we are still conscious of a resistance, our sense of it being augmented by an extension of the surface moved, as in the act of fanning; while, if the air is in motion, we feel its pressure on the sail of a boat by the "pull" of the sheet we hold in our hand, or on the sails of a windmill by the rotation it imparts, the *force* of which we can estimate by the *effort* we must put forth to resist it. Attenuate any kind of air or gas as we may, its resistance can still be made apparent by the like communication of its own motion to solid bodies. Thus, in Mr. Crookes's wonderful radiometer, a set of vanes, poised on a pivot within a globe of glass exhausted to *a millionth* of its ordinary gaseous contents, is whirled round by the movement excited in the molecules of that residual millionth, either by the heat of the radiant beam falling on the surface of the globe or by the passage of an electric current across its interior; and the mechanical force required to impart that motion can be measured with precision, by bringing it into comparison with some other force (as that of gravity) of which we can take immediate cognizance. And thus, as Herbert Spencer remarks, by the decomposition of our knowledge of any form of matter into simpler and simpler components, we must come at last to the simplest, to the ultimate material, to the substratum; and this we find in the *impression of resistance* we receive through what we may call our "force-sense." *

* Herbert Spencer considers the congnition of resistance to be essentially derived from the sense of muscular tension. I have already expressed my reason for now dissenting from this view, which I myself formerly held.

Such being the teachings alike of general and of scientific experience, I can not but feel surprised that any persons claiming the title of philosophers should affirm that we *know* nothing except matter and motion, and that force is a creation of our own imagination. One might suppose such persons to be either destitute of the "force-sense," or to have based their philosophical system upon the movements of the heavenly bodies which they can only *see*, instead of upon those mundane phenomena in the cognition of which they can bring their *hands* to the assistance of their eyes. How essential this assistance is to the formation of correct conceptions of the solid forms and relative positions of the objects around us is known to every one who has studied the physiology of the senses. Should we not think it absurd on the part of any one who possesses in the use of his hands the means of detecting the error of his visual perceptions, if he were to base a superstructure of reasoning—still more to found a whole system of philosophy—upon the latter alone? Yet such appears to me to be the position of those who deny our direct cognition of force.

Let us suppose (if possible) a man who had enjoyed the full use of his eyes, but whose limbs had been completely paralyzed from infancy, looking on at a game of billiards. He would see a succession of motions connected by regular sequence—the motion of the arm of the player, the stroke of the cue, the roll of the ball, its contact with another ball, the movement of the second ball, the change of direction or the entire stop of the first, the rebound of balls from the cushion in altered directions, and so on. And he might frame a statement in "terms of motion" of all that passes before his eyes, thinking this all he can know. But suppose the limbs of such a man to be suddenly endowed with the ordinary powers of sensation and movement; let him take the cue into his hands and himself strike the ball; let him hold his hand on the table so that the rolling ball shall strike it and make him feel its impact; let him hold the second ball and feel the shock imparted to it by the stroke of the first. Can any one deny that he would thus acquire a dynamical conception linking together the whole succession of phenomena, which he was previously quite incapable of forming; that this dynamical conception is quite as directly based upon the experience derived through his "force-sense" as his kinetic expression was upon that derived through his visual sense; and that this cognition of the force producing the motions is, therefore, fully as much entitled to be introduced into a logical doctrine of causation as the visual cognition of the motions themselves? If it be replied that we have no proof that the movement of the ball we strike is produced by the force which we consciously exert in striking it, I simply rejoin that we have as much proof of it as we have of anything which rests upon universal experience, and which we can verify experimentally as often as we choose to try—quite as much as we have of the existence of anything whatever that is external to ourselves.

Let us take, again, the simple case of magnetic attraction. A man who knows nothing of magnetism sees a piece of iron, brought within a certain distance of what looks looks like a horseshoe bar of the same metal, suddenly jump toward its approximated ends; and might, as before, correctly express the fact in "terms of motion." But let him take the piece of iron in his hands, so as to feel the "pull" upon it when brought sufficiently near the magnet, and he then becomes conscious, through his force-sense, of a *power* of which he was before utterly ignorant.

Thus, as it seems to me, an analysis of those *psychical* experiences on which all our cognitions of the *physical* universe around us are really based irresistibly lands us in the conclusion that, as Herbert Spencer expresses it, "All the sensations through which the external world is known to us are explicable by us only as resulting from certain forms of force"; the direct derivation of our conception of force from our own experience of muscular tension (or, as I should myself say, from our own sense of effort) being "a fact which no metaphysical quibbling can set aside." In the words of the able American writer I have already quoted, "The conception of force is one of those universal ideas which belong of necessity to the intellectual furniture of every human mind." By no one has the principle for which I am contending, been more clearly and more authoritatively expressed than by Sir John Herschel, a philosopher who united to his wonderful grasp of Nature-phenomena a profound insight into the action of the mind of man in the interpretation of them:

> Whatever attempts have been made by metaphysical writers to reason away the connection of cause and effect, and fritter it down into the unsatisfactory relation of habitual [unconditional] sequence, it is certain that the conception of some more real and intimate connection is quite as strongly impressed upon the human mind as that of the existence of an external world, the vindication of whose reality has, strange to say, been regarded as an achievement of no common merit in the annals of this branch of philosophy. It is our own immediate consciousness of *effort*, when we exert force to put matter in motion or to oppose and neutralize force, which gives us this internal conviction of *power* and *causation*, so far as it relates to the material world.—(Treatise on "Astronomy" in Lardner's "Cyclopædia," p. 232.)

Man's position as the "interpreter of Nature" may be not inaptly likened (as it seems to me) to that of an intelligent observer of the working of a cotton-factory, with whose mechanical arrangements he is entirely unacquainted, and of whose moving power he knows nothing whatever. He is taken into a vast apartment,* in which he is at first utterly bewildered by the number and variety of the movements going on around him; but, by directing his attention to the several

* In one of the flax-spinning mills belonging to the Marshalls, of Leeds, the whole of the work is done on one floor, covering, I believe, two acres of ground, instead of in the usual building of several stories.

machines, *seriatim*, he is able to arrive at a *classification* of them, according to the *kind of work* which it does. Thus he finds one set *carding* the cotton-wool supplied to it, so that its confused tangle gives place to a parallel laying of the fibers. He would see another taking up the bundles of carded wool, and *drawing* them out (after repeated doublings to secure uniformity) into a long, soft cord. This cord he would then trace into the *roving*-machine, which, by a continuation of the drawing process, further reduces its thickness, at the same time giving it a slight twist to increase its tenacity, so that it admits of being then wound upon bobbins. Thence he would trace the cord into the *spinning*-machine, which at the same time stretches and twists the cord, producing from it a yarn whose fineness might vary considerably in different machines. Finally, he would see the spun yarn carried, some as weft and some as woof, into the *power*-loom, from which it emerges as woven cloth—the final resultant of the whole series of operations.

Concentrating now his attention upon any one of these machines, he studies its wheels, levers, and other moving parts, and tries to comprehend their several actions and the bearing of these upon each other. By long and scrutinizing observation he masters the whole series of sequences, and traces the distribution of motion from a single large axis, through the hundreds (it may be) of separate pieces of the machine directly or indirectly connected with it; and he might thus frame a description of the working of the machine, which might be perfectly correct so far as it goes, and which yet would be defective in one most essential particular—the statement of the *force* or *power* by which it is moved. For, so far as mere visual observation could teach him, the machine might be self-moving; and he might thus attribute to each kind an *inherent power* of carding, roving, drawing, spinning, or weaving, as the case might be.

Carrying his observations further, and noticing that one or another of these machines comes to a standstill, but resumes its motion after an interval, he may include this occasional suspension also in his general expression; but, perplexed by the want of any regularity in its intervals, he will seek some further explanation. Continuing his patient watch, he will see that the stoppage of the machine follows the pulling of a handle by the man in attendance upon it, and that, when the handle is pulled the other way, the machine goes on again; and thus he will be led to introduce a certain position of this handle as one of the antecedent conditions of the machine's action. Still pursuing his inquiries, he finds out that the axes of the several machines are all in mechanical relation with one great longitudinal shaft, being connected with it either by continuous bands passing around pulleys, or by trains of wheelwork; and at last he discovers the important fact that the movement of the handle which stops the machine breaks the continuity of that relation, shifting a strap from a "fast" to a "loose" pulley, or throwing the wheelwork "out of gear"; while the converse movement, which restores that continuity, is followed by the renewed action of the machine, which goes on until the continuity is again broken. Thus he will be led to regard its maintenance as essential to the working of the machine; but nothing that he has yet learned explains to him *why* it is essential. He has only got at the *material collocation* which his educated vision enables him to recognize; and, for anything he knows to the contrary, the change in that collocation may be *in itself* adequate to determine the result.

But let him lay hold of the band which stretches between the main shaft and the axis of one machine, or attempt to stay with his hand the rotation of the train of wheels which connects it with another—he then at once becomes conscious, through his "force-sense," of the *power* which the band or the wheelwork is the instrument of conveying; and as he finds that the "pull" upon his hand is just the same whether the machine is in motion or not, provided that the band or wheel remains in mechanical connection with the main shaft, he comes to the conviction that the *source* of the power is in the shaft, and that, so far from any one of the machines having an inherent power of movement, its motion entirely depends upon the force supplied to it from the shaft. And when, under the guidance of this conception, he again examines the *working* of the several kinds of machine, he finds that, while the *power* is the same for all, the diversity in their respective products is traceable to the diversity in their construction—that is, to the *material collocations* through which the one moving force exerts itself in action.

But, having thus acquired the notion of *moving power*, and having satisfied himself of the derivation of the force that gives motion to each of the entire aggregate of machines, from one main shaft, our inquirer finds himself again posed. Has this shaft itself an inherent power of motion; or does it derive that power from any ulterior source? He sees the shaft apparently terminate in the two end-walls of the building; and, finding no evidence of its connection with anything else, he may feel himself drawn toward the conclusion that it moves *of itself*—that is, by the "potency" of its own material constitution. But, before adopting this *rationale*, he sees all the machines stop at once, and finds that the shaft also has ceased to revolve. Here is a new and startling phenomenon. After pondering on it for an hour, and carefully looking out for an explanation, he sees the shaft and its connected machines resume their motion, and yet is certain that no agency visible to him has had any concern in that renewal. By continued watching, he finds this suspension and renewal to be periodical, so that he can frame a law that shall express them in terms of *time*. Thus he might give a complete *phenomenal* account of the action of the shaft which should be perfectly consistent with the assumption of its "inherent potency," and which might be sufficiently satisfactory to his mind to justify him in believing that there is no more to be learned about it. But, not wishing to leave anything uninvestigated, he goes round to *the other side of the wall*. There he finds that one end of the shaft comes through it, and is in mechanical connection with either a steam-engine or a water-wheel; and, by watching what occurs when its motion is checked and renewed, he sees that the engineer shuts off, or turns on, either the steam generated in the boiler of the steam-engine, or the descending water whose motion drives the wheel.

I shall not weary the patience of such readers as may have followed me thus far, by tracing out in like detail the further steps of the inquiry, but shall land them in the final conclusion now accepted by every man of science—that the power exerted in both these cases is drawn from solar radiation: the fall of the water which gives motion to the water-wheel being merely the return of that which has been pumped up as vapor by the sun's heat; while the combustion of coal from which steam-power is derived reproduces, as active force, or "energy," the sunshine that exerted itself during the Carboniferous period in dissociating carbonic acid and water into the hydrocarbons of coal and the oxygen of the atmosphere, whose recombination gives forth heat and light. And, if we look still further back for the source of the sun's radiant energy, we should find it, perhaps, in the progressive consolidation of the primeval "fire-mist"—nebular matter.

But whence nebular matter? And whence the force which draws its particles together, and which manifests itself as light and heat during their consolidation? Here we come to a wall, to the other side of which we seem at present to have no access.

But *is* there no other side? Does not the whole course of the preceding inquiry show the unsatisfaction (if I may revive an obsolete word) of resting in any inherent "potency" of matter as the *ultima ratio* of the existing cosmos? If we think the man foolish who supposes the main shaft of a cotton-mill to turn *of itself*, merely because he sees it apparently end in a wall which conceals from him the source of its motive power, are we not really chargeable with the like folly if we attribute self-motion to the ultimate molecules of matter, merely because the power that moves them is hid from our sight? The mere physicist may see no possible way further. But there is a philosophy which has fully as true and as broad a basis in man's psychical experience as can be claimed for the fabric of physical science; and, in the admirable words of the great master I have already quoted (Sir John Herschel, in his "Familiar Lectures on Scientific Subjects," p. 460), I shall sum up an argument which this paper is intended rather to illustrate and enforce by an appeal to the familiar facts of consciousness than to present in strict logical form:

In the *mental sense of effort*, clear to the apprehension of every one who has ever performed a voluntary act, which is present at the instant when the determination to do a thing is carried out into the act of doing it, we have a consciousness of immediate and personal causation which can not be disputed or ignored. And, when we see the same kind of act performed by another, we never hesitate in assuming for him that consciousness which we recognize in ourselves; and in this case we can verify our conclusion by oral communication. . . . In the only case in which we are admitted into any personal knowledge of the origin of force, we find it connected (possibly by intermediate links untraceable by our faculties, yet indisputably *connected*) with volition, and, by inevitable consequence, with *motive*, with *intellect*, and with all those attributes of mind in which personality consists.

As a physiologist, I most fully recognize the fact that the physical force exerted by the body of man is not generated *de novo* by his will, but is derived from the oxidation of the constituents of his food. But holding it as equally certain, because the fact is capable of verification by every one as often as he chooses to make the experiment, that, in the performance of every volitional movement, that physical force is put in action, directed, and controlled by the individual personality or *ego*, I deem it just as absurd and illogical to affirm that there is no place for a God in nature, originating, directing, and controlling its forces by his will, as it would be to assert that there is no place in man's body for his conscious mind.—*Modern Review.*

NEW VIEWS OF ANIMAL TRANSFORMATIONS.*

By EDMOND PERRIER.

ONE of the results of teaching at the Museum is, that it always has considerable influence upon the teachers themselves. Forced by the nature of this institution to keep himself constantly acquainted with what is known and what is sought, with what is definitely acquired to science, and with the object of aspiration, obliged to coördinate recent with preceding discoveries, to test theories, to bind together the new material continually accumulating about the stones forming the vast edifice of science, the professor sees the lines of this structure slowly modified, he himself contributing to this result, and sometimes ends his career under the sway of other ideas than those which at first inspired him.

I confess that this has been my experience. Last year I began a series of investigations upon transformation. I had not taken sides upon this doctrine. If some general ideas had drawn me toward it, I had ever present the reiterated objections of the most illustrious French naturalists, among whom were the men I most love and venerate. But, as I proceeded with my lectures, it seemed to me that these objections were not insurmountable, that they did not touch the foundations of

* Introductory lecture to a course on Zoölogy at the Museum of Natural History in Paris, delivered March, 1879.

the doctrine, and belonged rather to the way of conceiving that the evolution of organisms has taken place. Looking not for differences but relationships among organisms, I thought I saw that a simple and general law had governed their formation, that they were derived one from another by a constant procedure, and I found myself adding further arguments to the theory of the genealogical origin of species. The law which I now have to put forward may be called the law of *association;* and the process by which it works, *the transformation of societies into individuals.*

When we have proved that all living beings are composed of microscopic corpuscles more or less alike, when we see such corpuscles capable of leading an independent life constituting by themselves the simplest organisms, it occurs to us to compare the higher animals and vegetables to vast associations of distinct individuals, each represented by one of these corpuscles or cells. In the same animal the cells assume many different forms, having different physiological properties. These forms and properties are not modified by the vicinity of different cells. Within the organism each cell lives as if it were alone. If it were possible to isolate a cell of the human body and surround it by normal nutritive material, it would continue to live, to develop and reproduce itself, and carry on all its physiological functions exactly as before. Further, in the organism itself, the life of each cell is so independent of that of its neighbors, that we may kill all the cells of one kind without injuring the others. Claude Bernard has proved that curare poisons the elements that terminate the motor nerves, thus abolishing all movement without injuring any other part of the system and leaving sensation intact. These researches led him to the principle of the *independence of the anatomical elements.* Not only are the elementary individuals of organisms sometimes very dissimilar, but they preserve their personality, live their own way, and keep up with their fellow citizens the relations of good neighborhood. We may compare an animal or plant to a populous town, where each person practices a particular industry on his own account, and yet helps the general prosperity through the activity of exchange. In high organisms, a special corporation in ceaseless movement is the medium of these exchanges. The blood-globules are true traders, taking along in the liquid where they swim the complex merchandise in which they deal.

Just as we had employed all the comparisons that pedigree furnishes to express the likenesses among organisms before supposing them really to be blood relations, so we have compared organisms to societies and societies to organisms, all the while regarding these comparisons as mere fancies. On the contrary, in the last year, we have reached the conclusion that *association* has played an important if not exclusive part in the development of organs. We find convincing proof of this in the history of Polyps and of Worms. The connection of Worms with the Articulata is apparent to every one, and we already see how these same Worms are related to Mollusca and Vertebrata. The theory, therefore, extends to the entire animal kingdom.

Now, what do we mean by association? When we say that animal organisms have been in great part produced by the transformation of animal societies into individuals, what do we mean by the term *society?* Are all societies in the way to become individuals? Many animals associate together, and their societies are sometimes admirably governed. The social manners of dogs, antelopes, beavers, and many birds are well known, while the complex and perfectly coördinated operations of societies of bees, ants, termites, are the admiration of the world. Do such societies ever become individuals? Certainly not. But there exist other animal societies in which the relations are closer—where the individuals are not only in immediate contact but in continuity of tissue with their neighbors. These societies are called colonies, but the individuals that compose them are not always indissolubly united together. They can separate from their companions, and live a long time and affirm their independence by forming new colonies. In the same zoölogical group of neighboring species, we find some individuals that always live solitary and others always associated, as for example the specially remarkable group of Polyps or Acalepha.

One species of this group, the brown Hydra (*Hydra fusca*), is common in stagnant waters and even in small garden basins. It has always excited the interest of naturalists and philosophers since Trembly made known its marvelous faculties. These Hydras ordinarily live solitary; but frequently the larger individuals are seen carrying smaller ones on the walls of their bodies. In a captured Hydra we can follow their development step by step. They are at first simple swell-

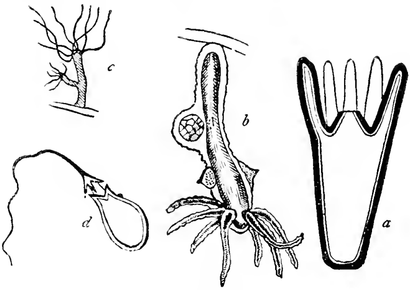


FIG. 1.—*a*, diagrammatic section of Hydra; *b*, *Hydra viridis*, showing swellings in the body-wall; *c*, *Hydra vulgaris*, with an undetached bud enlarged; *d*, thread-cell of the Hydra, greatly magnified.

ings, in the center of which there is a prolongment of the cavity of the mother's body. These swellings enlarge and soon put out tentacles, and a mouth opens in the midst of the crown formed by them.

The young Hydra, like its mother, is a simple sac with its wall composed of a double layer of cells, the cavity or stomach communicating directly with the stomach of the mother, so that the contractions of the body carry all the food taken by one into the stomach of the other, and inversely (Fig. 1). The parent and child live awhile in this way, but, whenever the latter has reached a certain size, it is detached and fixes itself on some near object, where it hunts on its own account. Soon the parent and offspring are indistinguishable, and during the summer they never cease to produce new Hydras. But, sometimes, in fertile waters rich in game, each Hydra retains its progeny, the little ones grow and produce new Hydras in their turn, and thus a new colony is founded. Trembly kept a long time a Hydra that carried twenty-two young ones of four different generations—a living genealogical tree.

That which is accidental in the common Hydra is quite normal with another fresh-water species, the *Cordylophora lacustris*, and in most marine Hydroids, in which the colonies often consist of innumerable individuals. But then new phenomena are seen. The social life becomes complicated, and a true *division of labor* occurs among the members of the same colony. At first all were alike, performing the same functions in the same manner. Specialization soon begins: some hunt, others digest, others reproduce; so that individuals that at first had no need of each other and lived united only in a careless way, become reciprocally necessary; the society thus acquires coherence and solidarity. In the Hydractinia we count not less than seven sorts of individuals: 1. Nourishers or gasterozoids; 2. Prehensers or dactylozoids, provided with bunches of stinging capsules; 3. Dactylozoids without stinging capsules; 4. Defenders; 5. Reproducers of individuals of both sexes; 6. Males; 7. Females. They are different in shape as well as in function; each taking the figure suited to its work, rising or falling in organization; so that *division of labor* brings with it, as in human society, inequality of conditions. The species thus become polymorphic.

Of these seven sorts of individuals that compose a colony of Hydractinia, the nourishers alone seem capable of living by themselves. The others have neither mouth nor tentacles, the sexual individuals are reduced to simple sacs, the defenders seem to be only sharp spines, between which the polyps can hide themselves (Fig. 5). It may seem an exaggeration to attribute individuality to these different parts. It may be said that they are simply organs; but organs of what? They are just as independent of each other, just as independent of the nourishers, as the latter can be of one another. They are, then, not organs of those Polyps. Can they be organs of the colony? It is already understood that the colony has the character of an individual, and the transformation we seek to demonstrate is admitted. But how can a colony acquire organs? Whence can they arise except from a transformation of the individuals which compose it? We have no need of hypothesis, however, to demonstrate that these *colonial organs* are the equivalents of true individuals. The buds that give birth to the different sorts of individuals in a colony of Hydractinia all grow alike, and re-

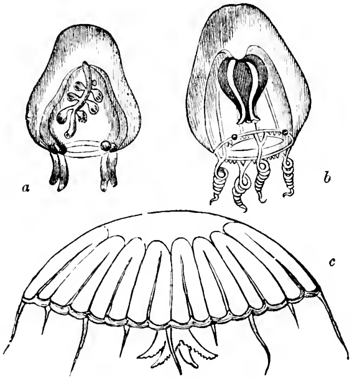


FIG. 2.—NAKED-EYED MEDUSÆ.

main alike for a long time. This is the first presumption in favor of their equivalence. But in the allied type, *Podocoryne*, we see the humble sac, which represents the sexual individual, replaced by a being more active, more elegant, much more elevated than the Hydra itself, by a transparent medusa, which is detached when it reaches maturity and swims actively in the water, the colony suffering no inconvenience from the change (Fig. 2). These medusæ constitute the most general

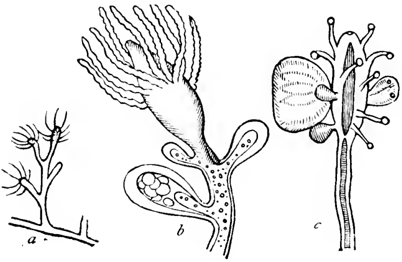


FIG. 3.—*a*, fragment of *Cordylophora lacustris* slightly enlarged; *b*, same, showing gonangium; *c*, portion of *Syncoryne sarsii*, with medusiform Zoöids budding between the tentacles.

form of the sexual individuals in the group of Hydroid Polyps, but they are very polymorphic. Their form is modified from one species to another, and arrested at all stages of development. Sometimes, although completely formed, they resign their freedom and end their existence in the colony where they were born.

In one group of Polyps the Medusæ associate themselves with the reproductive individuals to form a new unit—a small, distinct colony, that might be taken for a peculiar organ curiously analogous to a

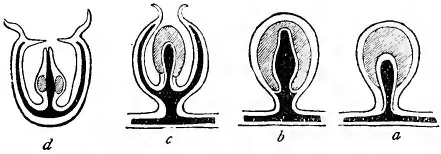


FIG. 4.—GENERATIVE BUDS OR GONOPHORES OF THE *Hydrozoa* DIAGRAMMATICALLY REPRESENTED. *a*, simple gonophore; *c*, gonophore which has the structure of a Medusa (medusoid), but is not detached; *d*, free medusiform gonophore.

flower—with a separate chamber, and called the *gonangium* (Figs. 3 and 4). A step further and these strongly individualized Medusæ are seen descending to the rank of organs in more complex colonies.

All the colonies of Hydras are not fixed to submarine objects. Some of them lead a vagabond existence. They are often taken, not without reason, for simple animals analogous to the Medusæ, and called

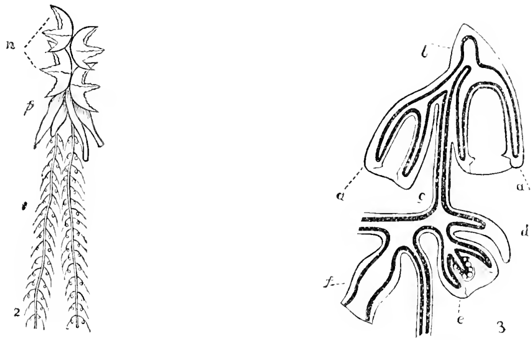


FIG. 5.—OCEANIC HYDROZOA, SHOWING THE SPECIALIZATION OF PARTS. 2, Siphonophore; *n*, swimming-bells; *p*, alimentary region; *t*, tentacles; 3, diagram of the composite body of one of the Siphonifera: *a a*, swimming-bells; *d*, spiues or defensive individuals; *f*, digester.

Siphonophores (Fig. 5). They sometimes attain a large size; and the variety and profusion of the parts which compose them, as well as the brilliancy of color and incomparable beauty of their forms, have made them subjects of the profound admiration of naturalists as well as sailors (Figs. 6 and 7). Each one of these parts is the equivalent of a

Hydra or of a Medusa. In one *Agalma* we find, as in the Hydractinia, nourishers supplied with one long tentacle, of which a single touch produces a severe burning sensation, a sort of fish-line, which in large species is capable of capturing fishes. Besides the nourishers,

FIG. 6.—HIDDEN-EYED MEDUSA.

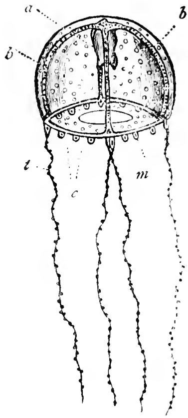


FIG. 7.—GONOPHORE OF ONE OF THE *Campanularida.*

are found individuals without a mouth, which are only reproducers, in the neighborhood of which are sexual individuals resembling Medusæ in form. All these individuals are fixed upon a common axis, which floats like a serpent in the water, where it is sustained by an air-vessel forming its superior extremity. Two series of sterile Medusæ appear underneath this bell, a gang of oarsmen (physales), to which the colony abandons the care of locomotion.

These various parts are in all respects too much like the Hydras and Medusæ for us to refuse them the character of individuals ; the Agalma and other Siphoniferæ are true societies or colonies. But here most of the individuals can not separate themselves without danger of death ; and, in certain cases, they all coördinate their movements that the colony may perform certain acts. For example, in the Portuguese men-of-war (Fig. 8) the physales frequently change their course, and then all the individuals of the colony concur in the operation. They have, then, a will which controls them—a will that can find the grounds of its decisions only in a sort of social consciousness, elevating the colony to the rank of a psychological unit. Composed of individuals each of which is equivalent to those Hydras or Medusæ that live free and isolated and sufficient for themselves, every Siphonophore must still be considered in its turn as a single animal

—a true individual of a higher order. Here the transformation of the colony to an individual is manifest. The Siphonophore is an animal with organs made up of distinct animals, each having a particular function. Elsewhere we see these animal organs become less and less independent. They come together and arrange themselves around a central axis which predominates, and end by forming a being like the Porpita or Velelle, which, but for the study of neighboring types, would not be thought of as a decomposable animal.

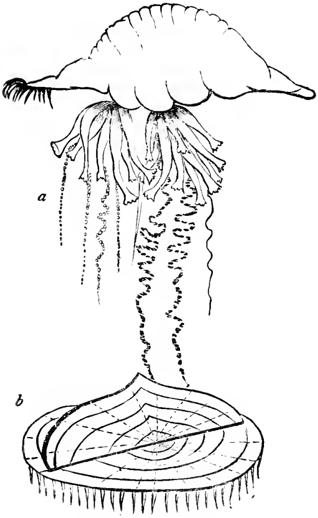


Fig. 8.—*a*, Portuguese man-of-war (after Huxley); *b*, *Velella vulgaris* (after Gosse).

At the present time most people consider Sea-anemones (Fig. 9) and Polyps, of the madrepores, and coral, as simple organisms—primitive individuals; while to us their origin is the same as that of *Porpitæ* and *Velellæ*—the union of three sorts of Hydroid Polyps. The admirable researches of Moseley on the Polyps of the family of *Stylasteridæ* furnish proof of this. If we consider only their calcareous parts, all these beings seem to be true Madrepores. The first doubt concerning their true nature was raised by Agassiz, with reference to the Millepores.

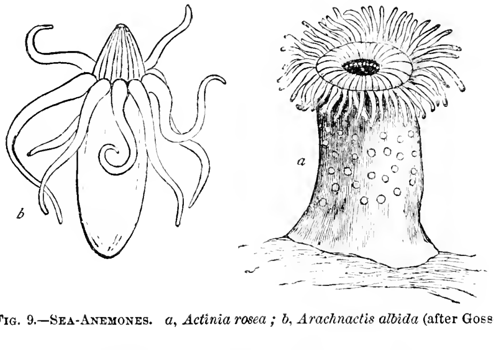


Fig. 9.—Sea-Anemones. *a*, *Actinia rosea*; *b*, *Arachnactis albida* (after Gosse).

Between a Coralarian and a Hydroid Polyp the difference is considerable. One is a simple sac with tentacles, usually solid appendages of the wall of the body, that vary in number with the species, or sometimes with individuals, but are constant for each during the great part of its life. The other is formed of a stomach-like sac, open at bottom, around which are hollow tentacles, which often increase in number with the age of the Polyp (Fig. 10). These tentacles, which are free at their extremities, and united at their bases to form the wall

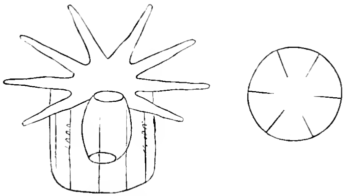


FIG. 10.—DIAGRAMMATIC FIGURE OF SEA-ANEMONE.

of the Polyp's body, open inward like the stomachal sac into a great cavity, the circumference of which is divided into cells by the soldered walls of two neighboring tentacles. On the partitions of these cells, and so within the body, the reproductive apparatus is developed; while in Hydroid Polyps it is generally on the exterior in the form of a bud. This type of structure is much more complex than that of the Hydroid Polyp, which is well represented by the Stylasteridæ. In their colonies we find the polymorphism of the Hydroida, and also the nourishers, purveyors, and reproducers. Among the *Spinipora*, *Sporadopora*, *Pliobothrius*, *Errina*, these different sorts of individuals are perfectly independent of each other: a simple vascular network distributes among them the food seized by the hunters and elaborated by the nourishers.

But with the Millipores the nourishers are the most important members of the colony, as they prepare all the nourishment, drawing around them the hunters and reproducers, but without establishing any more intimate relations. With the *Astylus*, the *Stylaster*, the *Cryptohelia*, this movement of concentration around the nourishers becomes pronounced; a space forms underneath; the tentacles, rendered useless by the neighborhood of the hunters, disappear, and nothing remains but a digestive sac around which the hunters perform functions exactly like those of the tentacles of a Coralarian Polyp. Each system has now a decided individuality. Another step, and the hunters, from being distinct throughout their whole length, grow together at the base and interlace with the digesters, and the reproducers follow in this movement. These different parts are, thenceforward, too near together to require a special vascular system; the vessels which unite them are simple perforations of their wall which open in the space just below the digesters, and into which the reproducers penetrate also. But this whole the most experienced naturalist could not distinguish from a Coralarian Polyp. Among Coral Polyps the individual is, then, an association of parts of different form, of which each is equivalent to a Hydroid Polyp.

A Coral Polyp with twelve tentacles is the sum of a considerable number of Hydroid Polyps—one digester, twelve hunters, and a variable number of reproducers. It is formed by the aid of Hydroid Polyps, as flowers by the aid of leaves; or, better yet, as the composite flower is formed by its florets. It is produced in the same way as the Porpita or the Velella; the *formation of a colony*, the *division of physiological labor*, the *appearance of polymorphism*, and the *concentration of the parts so elaborated*—such is the succession of phenomena which marks the transformation of Hydroida into Velellæ and Sea-Anemones. The Hydroid Polyps are the raw materials which are brought into the factory, and then fashioned and gathered together to form higher individualities.

While these morphological phenomena are taking place, others are also occurring in a physiological order. At first the associated individuals have nothing in common except nourishment, which all are capable of elaborating, but which passes from one to another so that all are equal partakers. It is just here that consolidation begins, but each polyp still preserves his personality. He has his own will, and does not share his sensations with his neighbors; we can wound or even remove one without disturbing the rest. But, in proportion as the colony becomes more coherent, sensations extend farther and farther around the polyp that experiences them. Soon all the individuals

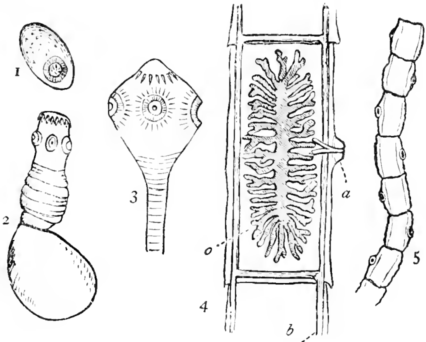


FIG. 11.—MORPHOLOGY OF TAPE-WORM. 5, fragment of tape-worm showing the joints; 4, single joint enlarged showing ovary, *o*, generative pore, *a*, and canals, *b*; 3, head of tape-worm.

are conscious of that which happens to any one of them, thus forming a colonial consciousness above that of the individual, and finally a single will bends all the special wills to its bidding. A new individual is now definitely constituted. Is not this the same law which presides over the transformation of savages into civilized people? Have not nations, corporations even, a consciousness and will? Do they not form great units which we designate by one word in current language?

The transformations we have followed step by step in the class of Polyps are not restricted to these animals. It is easy to show how

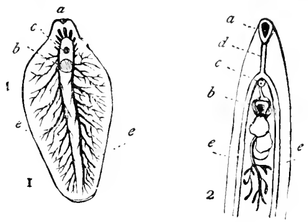


FIG. 12.—TREMATODE WORM.

simple forms are again associated, in the group of Worms, to obtain the more complex forms. We find here the same laws as in studying the Polyps. Long ago, Van Beneden, Professor at the Catholic University of Louvain, affirmed that each joint of a tape-worm (Fig. 11) was

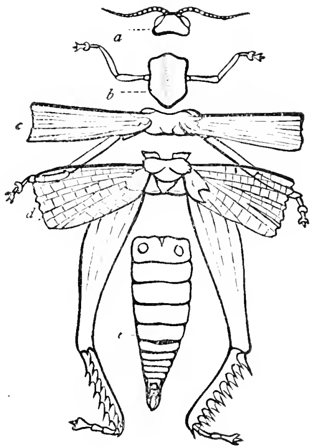


FIG. 13.—SOMITES OF INSECT.

the equivalent of a Trematode worm (Fig. 12); and Douve still earlier taught that the rings of a worm, or of an insect, were considered by naturalists as equal units, formed of the same parts, having each a real individuality. The name Somites, which has been given them, shows the tendency to consider them as true elementary animals associated in colonies (Figs. 13 and 14). The power possessed by the segments of certain worms to individualize themselves and form new colonies is strong evidence in favor of this view. Polymorphism and the concentration of parts explain how a *Peripatus* or a *Myriapod* can

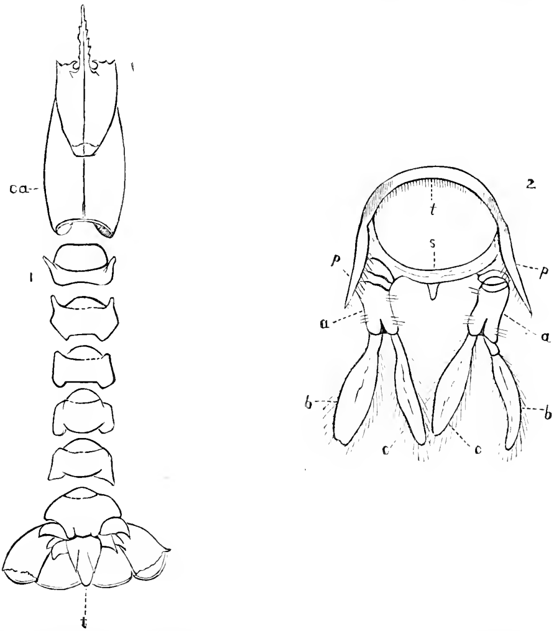


FIG. 14.—LOBSTER WITH THE SOMITES SEPARATED FROM EACH OTHER, THE APPENDAGES BEING ALL REMOVED EXCEPT THE TERMINAL SWIMMERETS. *ca*, carapace; *t*, telson; 2, third abdominal somite with its appendages.

become a spider or an insect, how different Crustacea arise from a common stem, how from another form of colony have arisen all the Annelida. It has been often said that Echinoderms, Star-fishes, Ophiurans, were only colonies united by the head (Fig. 15). They are, at least, all colonies, but of a special nature.

Can we say as much of the Mollusca and Vertebrata, all the parts of which are so closely united, and which are the giants of creation? Are there simple forms of association which can explain the marvelous organization of these superior types of creation—as we have explained the Siphoniferæ, Coral Polyps, Echinoderms, and Arthropoda?

This is the question for our present course of lectures ; but, whatever the result of our inquiries, it will not invalidate the generality of the principle of *association.* If, contrary to our past opinions, these higher beings are not simple individuals, we must compare them with

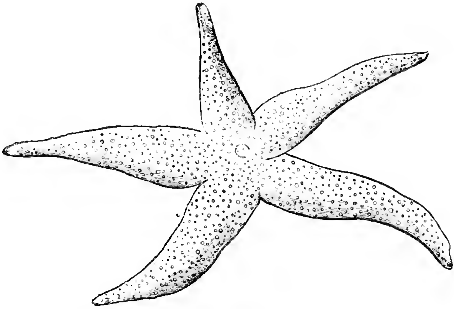


Fig. 15.—Star-fish.

those primordial individuals which by combination have produced other types, and which are still found at the base of each of the great divisions of the animal kingdom. Now, how have these individuals arisen?

The Hydras and analogous organisms reply. We can cut a Hydra into as many pieces as we like, and each piece, instead of dying, continues to develop and ends by becoming a complete Hydra. It follows that these different parts are independent of each other, like the polyps forming the lowest colonies. Each cell of the Hydra is a true individual, and the Hydras are a colony of these monocellular individuals as the Siphonophores themselves are colonies of Hydras. Aptitude to social life is communicated by heredity to these cells, as it is communicated to the polyps. Each cell, each polyp, detached from the colony, is a copy of it, and his after-development tends always toward its formation. At first all the members of a colony are equally apt to reproduce ; then this function is localized like the others, and pertains to some individuals, or some parts, while sexual reproduction becomes more and more important. When the society reaches a certain degree of coherence, these different parts cease to live independently of the others, and can not be separated without danger of dying.

We see still more clearly in the Sponges their colonial nature. The spongarian individual is formed of two sorts of cellular individuals, the amœba and infusorial flagellifere, of which we find analogues living, at liberty and in isolation (Fig. 16). The flagelliferous cells of sponges present exceptional features ; they are provided with a nucleus and contractile vesicle, and their unique flagellum is surrounded by a membranous collarette in the form of a funnel. All these characters are found in the *Codosigæ*, monocellular Infusoria, always living isolated, and are to the sponges what the Hydras are to the Siphonifera and Coral Polyps. In the *Anthophysæ* these cellules live in colonies, but are yet all alike. Let polymorphism step in. Let some of the asso-

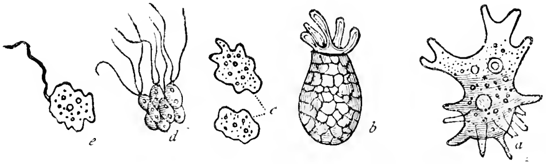


FIG. 16.—*a* and *b*, Amœbæ, *c*, *d*, *e*, sponge particles.

ciated cells preserve the flagelliferous form, while others become amœbæ, a transformation which is possible, since it constitutes one of the most frequent modes of reproduction of the amœboid Infusoria, and the *Anthophysa* is transformed into a sponge. The process is always the same, whatever the nature of the assembled materials. Cells or polyps, it always submits to the same elaboration in developing new individuals. The cells, once assembled in the organism, yield easily to the changes required by the division of physiological labor, and form various organs, although these organs never become true individuals. If the individuals of a colony often descend to the state of organs, we must not conclude that the organs of an animal are always individuals that have lost their autonomy; but the animal to which they belong, though it may never have been an assemblage of individualities intermediate between its own and that of cells, is not less a colony of the latter subjected to the laws of evolution of all the others. Thus even if we can not prove that Vertebrates and Mollusks have resulted from the fusion of more simple beings that have lived an independent life, they are still colonies of cells, and the *law of association* has consequently lost none of its generality.

It remains the fundamental law of development in the animal kingdom, comprehending and controlling those *laws of growth*, of *organic repetition*, of *economy*, which have been long accepted by physiologists, explaining hitherto mysterious *homologies* between different parts of the body, or between different organs of the same animal; embracing in one circle all the forms of asexual generation, which are its most powerful means of creation. Resting upon the law *of the division of physiological work*, the importance of which was first demonstrated by Milne-Edwards, and upon that of *polymorphism*, which without it have only a limited and indefinite meaning, consequent on the law of division of protoplasmic masses, it has been the great producer of organization, and establishes a new link between sociology and the branches of biology that are occupied with the constitution and functions of organisms.

We now reach the ultimate elements of living bodies, the material which has served to make the most simple beings, and we ask, What is its origin? Here we are in the presence of unity; there is no longer any question of association. Most living cells are composed of four parts—a membranous envelope, a contained fluid in which is a special globule, and the nucleus, containing the nucleolus. Of these four parts only one, the contained semi-fluid, perfectly limpid or finely granular, the *protoplasm*, is indispensable. It is in this strange substance that life, which needs no other apparatus to manifest itself, resides. Those remarkable beings, the Monera, are formed of it alone. They are simple, homogeneous clots of a limpid jelly like the white of egg. This jelly has the power of movement, captures animals, digests and assimilates them, grows, and, when it has attained a certain size, divides into two or several masses, that begin anew the life of their mother, and divide like her when they have reached a certain size.

This faculty of division is an important property of protoplasm, because it governs all organic evolution. A protoplasmic mass can not exceed a determinate size. When it reaches this size, a partition forms, and, as its mass is perfectly homogeneous, as it is constantly traversed by currents that completely mingle its substance, all the resulting fragments possess the acquired or hereditary properties of the protoplasmic mass from which they came. This explains all the phenomena of *heredity*, by means of which each being transmits to its progeny, even in the case of sexual generation, all its specific and part of its personal characters.

From this incapacity of protoplasmic masses to exceed a certain length, it follows that all beings that are larger must be formed of several distinct masses of protoplasm—in a word, are colonies. So the generality of the law of association appears as a consequence of one of the fundamental properties of protoplasm. It constantly decomposes itself into distinct masses. These separate masses are modified, each in a particular fashion, under the influence of external agents. Hence the wonderful variety of nature is an immediate consequence of the law of association, of the necessity imposed upon protoplasm to separate into small distinct individualities.

What, then, can be the nature of protoplasm? Struck by its homogeneity, the identity of the elements that compose it with those that form albuminoid substances, it has been taken for a mere chemical compound, and it has been boldly asked if it is not possible to produce it artificially; if man has not power to relight the torch of Prometheus and create life at will. This question, I believe, has been asked in consequence of a strange confusion of words. If it is true that the substances that form living matter are the same as those that enter into certain chemical compounds, we can not infer from this that protoplasm is one of these compounds. What characterizes a chemical compound is fixity of composition. But protoplasm changes incessantly, without modifying any of its fundamental properties. New substances are constantly entering into its mass while others are leaving it. Protoplasm is perpetually decomposing and recomposing itself. It is this, and not its chemical composition, that characterizes it. It is always in movement, and motion characterizes life.

Life is, then, only a combination of movements, or, if you please, a mode of movement of which certain substances are alone capable, and which is not without analogy with the whirling movements to which eminent physicists attribute the properties of chemical atoms. We might pursue this comparison between atoms and protoplasms, and use it to show that the latter must have been formed originally in the greatest possible number; that we seem to be powerless to reproduce them; that they appeared with a train of properties which have controlled their subsequent destiny; and that they had from the first the individuality we see in them at the present day.

THE DUTY OF ENJOYMENT.

TO say that we are under a moral obligation to enjoy ourselves would be, in the opinion of most persons, to utter an unmeaning paradox. It is commonly supposed that the natural instinct for pleasure can take care of itself without any reënforcement from a sense of duty. More than this, our habits of thought instinctively lead us to set duty in antagonism to pleasure, so that to talk of a duty of enjoyment sounds self-contradictory. Many influences have combined in the past history of our race to produce this conception of the relation of pleasure and duty. Unless this idea had been developed and fixed in the human mind, it is difficult to see how the moral progress already attained would have been possible. Even that extreme form of this doctrine of the antagonism of pleasure and duty involved in the ascetic renunciation of all enjoyment as sinful was doubtless a useful and necessary belief in certain stages of social evolution. But it may be that this conception of pleasure has now lost its utility, and will have to be displaced by a view of life which sets a positive moral value on enjoyment. The epicurean theory that all good resolves itself into pleasure has long been before the world, and has won many adherents. Since the revival of letters many writers have contended warmly against the mediæval disparagement of pleasure. Of late years a number of writers with a keen appreciation of the æsthetic resources at our command have in beautiful and alluring language held up a refined hedonistic ideal of life, according to which all irksome sense of duty will melt away in a rational cultivation of choice delights ; and now a leading philosopher has added the weight of his name to this tendency of ethical thought by distinctly enforcing the duty of compassing a pleasurable existence, a duty which he thinks to be sadly neglected in these days.

The arguments put forth by Mr. Herbert Spencer in his latest volume, "The Data of Ethics," in support of the proposition that the cultivation of pleasurable consciousness is a prime duty of life, will be sure to excite a good deal of attention. His fundamental idea is that pleasure is good, because it is the accompaniment and mark of a healthy exercise of a useful or life-preserving function. Pleasures and pains have been attached to actions beneficial and injurious to the organism by the working of the laws of evolution. Since it is an inevitable law of our mental nature that we should seek pleasure, and since, too, it is a condition of self-preservation and survival in the struggle for existence that our actions should tend to organic efficiency, it follows that the coincidence of pleasurable and life-serving activities must from the first have been a necessary condition of permanent existence. Mr. Spencer thinks that people have altogether overlooked this truth. Even moralists who might be supposed to know better have, he conceives, failed to recognize the function of pleasurable feelings as guides to sound living. Men are excused, if not commended, when, in pursuit of some worthy distant object, they pay no heed to the bodily pain which should have told them that they were not fulfilling the first conditions of all efficient action. Again, pleasure is to be recommended as directly effecting an increase of energy, bodily and mental, as raising "the tide of life" ; yet moralists have altogether forgotten this when pronouncing their sweeping condemnations of pleasure as evil, or at least as of no moral value. Mr. Spencer appears to feel a genuine abhorrence of the ascetic conception of pleasure, for he speaks of the "tacit assumption, common to pagan stoics and Christian ascetics, that we are so diabolically organized that pleasures are injurious and pains beneficial." He does not attempt, as an evolutionist very well might have done, to account for the genesis and survival of the ascetic doctrine. Later on he dwells at some length on the importance of a due pursuit of individual enjoyment as a preliminary to an effective rendering of services to others. In this way he would erect the study of pleasure into a double obligation—a duty to one's self and to others.

Most readers will allow that there is much force in Mr. Spencer's reasonings. It may be doubted, however, whether the common neglect of pleasure as a good thing proceeds as much from lingering ascetic ideas as he supposes. In their severer form these ideas are confined to a few religious sects, and even among them they are not now enforced so rigorously as formerly. It is to be added that the modes of enjoyment more especially disparaged in this ascetic teaching are of very questionable value. It may be doubted, for example, whether much dancing, carried on into the small hours of the morning, or much frequenting of hot and badly ventilated theatres, conduces to a really pleasurable and efficient life. On the other hand, it deserves to be remembered, perhaps, that society distinctly puts its mark of approval on enjoyment by actually imposing the duty of pleasure-seeking on its individual subjects. Many a delicate woman will attend the social gayeties of the season because she is expected to enjoy herself in this way; and many a busy man will take his month or six weeks' holiday at a fashionable pleasure resort, not because he desires the kind of enjoyment offered, or even expects to realize it, but simply because society tells him to act thus. What makes people neglect pleasure much more than any form of ascetic prohibition is, we suspect, personal indifference arising from inattention and preoccupation. More particularly in our busy age, men are very apt to be absorbed in some exciting pursuit, so as to overlook the pleasurable resources of life. Often this engrossing pursuit, though entered on at first from a motive of pleasure, ceases to bring any appreciable enjoyment, and thus the whole life becomes to a large extent robbed of its proper emotional hue. Nor is this narrow and unreflecting disposition of opportunities and energies simply a loss of so much enjoyment. It commonly results in the accumulation of a large mass of pain. The non-satisfaction of natural tastes and impulses pretty certainly brings a vague sense of something wanting—a dreary feeling which depresses the mental tone and throws a gloom on life. Add to this that the state of mental absorption in some one line of activity is highly favorable to a neglect of all the many little circumstances which must coöperate in sustaining health. The first indication of this inattention to health is probably a development of abnormal nervous irritability. The temper is ruffled; sources of annoyance multiply, while those of gratification decrease in the same ratio. The full development of this change is seen in a morose view of life, which has the same practical results as a professed asceticism. There is a growing disposition to dwell on vexatious elements of experience, to nurse a sense of injury, and a corresponding disinclination to seek enjoyment, or even to accept it, when close at hand.

It seems to us that this neglect of the conditions of a full and pleasurable life is, as Mr. Spencer suggests, a thing to be severely deprecated on moral grounds. For there is no doubt that it leads in a number of ways to the infliction of suffering on others. To have to live with an irritable and gloomy person is probably as great an affliction as to be burdened with a painful illness. Accordingly, a man who by inattention to the conditions of a cheerful frame of mind becomes the source of numberless vexations to his family may really produce as much suffering as many a well-recognized criminal. It is almost amusing to see how men will seek to excuse themselves for their carelessness in these matters on the ground that they are sacrificing themselves to some useful object, some form of public service. It may often be doubted whether even success in their endeavors would result in any benefits at all commensurable with the ills brought on their families. And in any case it may not unreasonably be contended that usefulness, like charity, should begin at home. A great novelist and moralist has recently satirized the common neglect of public interests by the English *paterfamilias* whose largest conception of public good is the welfare of his family. The case is no doubt common enough ; but its commonness must not make us overlook the evils of the other extreme, the carrying out of something which is supposed to be of public value at the cost of the comfort and enjoyment of the public benefactor's family and friends. If moral worth is to be estimated by the amount of happiness bestowed on others, it may well be doubted whether some of these self-sacrificing persons of large aims are not of inferior value to many a commonplace good-natured citizen, who is perfectly free from all lofty aspirations, who likes to live well and to surround himself by happy faces, and whose healthy instinct for pleasure leads him unreflectingly to add to the enjoyment of all who have to do with him.

In many cases, then, it is clear that people do not think enough of the simple pleasures of life. It may be added that, in order to realize in one's self and in others the full benefit of a pleasurable existence, it is necessary to pursue pleasure as something intrinsically desirable. It will not do to seek it merely as a means to an end beyond itself. Pleasure must be loved and sought in and for itself, if it is to be the good which it is capable of becoming. A man should be steeped in the atmosphere of happiness if he is to realize the efficient and beneficent existence we have described, and this presupposes what may paradoxically be called a disinterested liking for pleasure. It is by no means easy to persons of a certain temperament to cultivate the spirit of enjoyment in this way. In truth, it may be said to be the result of a difficult art which will only be acquired by those who have reached a high pitch of moral culture. To foster and manifest a cheerful and gladsome mind often involves a considerable amount of self-restraint in repressing and banishing those gloomy reflections to which one may be constitutionally prone. There is further a certain moral sluggishness and inertia in some natures which makes it a considerable effort to rise into the pleasurable strata of the emotional atmosphere. How often, for example, is a fit of mental depression only capable of being dissipated by a vigorous form of bodily exercise to the idea of which the feeling of the moment is strongly opposed ! The creation and sustentation of a bright and joyous consciousness is thus often a matter of real difficulty, and deserves to be extolled as a moral triumph over natural inclination.

It may be well to add that this conscious pursuit of a happy tone of mind will demand a good deal of individual self-assertion in the face of the claims of social custom. If a man is to succeed in being a radiant center of happiness, he must, it is plain, be free to seek enjoyment in his own way. We do not mean merely that he will naturally disregard the force of example so far as to avoid the extreme heat of the struggle for existence. It is only too obvious that, if he desires a healthy, cheerful condition of mind, he must take life in a measure easily and abandon all excessive ambitions. What is less obvious is, that he will have to hold aloof from many of the forms of fashionable enjoyment prescribed by society. These prescriptions are often exceedingly foolish, having no relation to individual tastes. For example, the late dinner-party, though supposed to be a source of enjoyment, is really adapted to induce in many persons a permanent feeling of depression and weariness. It would perhaps not be edifying to inquire how much of the chronic discontent and mental discomfort of people arises from a too ready compliance with the demands of fashionable society with respect to amusements.

But the reader may object that we are here taking only one view of our subject. Is it not, he may ask, a dangerous doctrine that pleasure is a good thing, deserving to be cultivated with ardor and assiduity? No doubt the pursuit of personal enjoyment must not be made the sole aim of life. To use Mr. Spencer's language, egoism must be balanced by altruism. Yet, while allowing this, we would contend that a wise and calm regard for a continuously happy existence is a much less inadequate guide to right living than many moralists are apt to think. They forget that the preservation of an habitual flow of pleasurable feeling is not possible where exciting indulgences are sought after as the chief thing in life. It is really a defamation of the idea of pleasure to call a sensual person addicted to wild excesses of enjoyment a man of pleasure. The true man of pleasure is rather he who tries to carry the atmosphere of enjoyment into all the circumstances and occupations of the day. Those who thus seek pleasure rationally, avoiding all fatiguing over-indulgence, and giving the highest value to the quieter and more expansive forms of enjoyment, will not perhaps greatly fail in a due consideration of others' interests. For, as Mr. Spencer has shown in this same volume, a considerable dash of altruism is a necessary condition of a full experience of personal gratification. This is true even in our present imperfect stage of social development. And if, as he thinks, and we would fain hope, things are tending to a complete formation of the social man with an adequate capacity of sympathy, it must happen by and by that the most thoughtful and judicious cultivator of personal happiness will at the same time be most serviceable to others. However this may be, Mr. Spencer has rendered a timely service in exposing the absurdity of an undiscriminating disparagement of the pleasurable disposition, and in showing how valuable an element in the economy of life, individual and social, is the instinctive impulse toward enjoyment. —*Saturday Review.*

INTEMPERANCE IN STUDY.*

BY D. HACK TUKE, F. R. C. P.

HAVING met from time to time with cases of brain-fag, and also actual insanity, arising from excessive mental work, I wish to direct attention to-day to this cause of disordered mind, not because it is so widespread a cause as many others, but because for this very reason it is in danger of being treated with indifference, whereas at the present moment I regard it as a serious evil, although comparatively restricted in its operation in consequence of the great mass of the people falling under opposite influences ; still I fear that it is in schools and colleges as well as in the cottage of the laborer and manufacturer, among students as well as among those who delve and spin, that we must seek for the causes of mental disturbance if we wish to understand them thoroughly.

It would occupy too much time to detail the cases to which I refer; I must ask you to take them as "read." For my present purpose it is sufficient to say that they have taken the form of brain-fag, mental excitement, depression of spirits (sometimes suicide), epilepsy, and chorea. I have recently known a case of acute mania distinctly due to this cause, confinement in an asylum becoming necessary. Of suicidal melancholia I could cite some painful instances, and, as regards epilepsy, I could detail the history of some marked cases resulting from overwork ; and I may state that, at the National Hospital for Epilepsy in London, pupil teachers have been admitted laboring under this disease, brought on by mental strain. Two medical officers, resident in the institution at different times, spontaneously drew my attention to the fact.

I fully admit that, in many instances of mischief from excess of study, this results from anxious worry as well. The subject "preys on the mind," as people say ; but then it was the study of too large a number of subjects or of subjects beyond the power of the student to master within a given time which was to blame for this harass.

Here I wish to anticipate an objection which may be raised to my own observation and experience on this question. How is it—it may be fairly said—how is it that, if over-mental work is often to blame for attacks of insanity, there are not more statistics at hand to prove it ? To this I would reply :

* Read in the Psychological Section at the Annual Meeting of the British Medical Association in Cork, August, 1879.

1. The principal statistics in regard to the causes of insanity are derived from asylums for the uneducated classes.

2. An attack of excitement caused by mental strain in the young is often temporary, and is treated privately.

3. When suicide is successful before the patient reaches an asylum, the case is not to be found in lunacy statistics.

4. Cases of epilepsy often remain at home; and the same remark applies, of course, to brain-fag and general nervous exhaustion.

In regard to one of these points I would observe that, when I have been able to examine into the causes of cases of insanity admitted into non-pauper asylums, I have found a considerable number traceable to excessive mental work either as a predisposing or an exciting cause. No doubt this is often associated, as I have just said, with anxiety and other emotional states. It is sufficient, however, for our present purpose if it be admitted that a considerable number of attacks occur in connection with overwork, although complicated with emotional excitement. It must be remembered that the mischief thus done is only one part of the evil wrought by the intemperate pursuit of knowledge. The lungs and other organs also suffer. Dr. Andrew Clark writes to me: "I am a witness to the grave and sometimes irreparable mischief done at schools and in working for competitive examinations. As an illustration," he adds, "of the evil effects of overwork for competitive examinations, I can say that, of the young men passing the Civil-Service Examination for Indian Service, and afterward sent to me by the Civil Service Commissioner for health certificates, ten per cent. during the last three years have had temporary albuminuria."

I have before me tabular statements of the school hours and the subjects taught in some of the principal English public schools, as well as in private seminaries. It is utterly impossible to present them to you in the brief period allotted me; I can therefore only offer a few general remarks upon them, and refer to two or three by way of illustration.

The number of hours actually spent in school does not (as a general rule) appear to be excessive in our large public schools. There are exceptions, but this evil and the multiplicity of subjects taught apply rather to the private schools. Where the chief danger seems to lie in most schools is in the encroachment made on the play-hours. In some day schools the lessons set to learn at home are absurdly long and tedious. I find that in other schools, public and private, a great deal of work is done during the period nominally allotted to recreation only. This is a very important part of the actual school-system, and one which requires great care on the part of masters. I will now take the school hours of the sixth form in one very excellent school for the middle and higher classes. There is an hour's work before breakfast, three hours in the morning, four hours in the afternoon, and two hours in the evening, making a total of ten hours for study. Between breakfast and supper there are about two hours allowed for recreation. While it must be remembered that, when we speak of boys being engaged in study for ten hours, those who are lazy are not closely and continuously engaged in their work, and that if the master is not strict the strain is not necessarily severe, I can not but think that it would be better for the health of the scholars in this school if the total amount of time engaged in school or study did not exceed eight or at most nine hours. I am quite alive to the danger attending too liberal an amount of time being left at the disposal of schoolboys; they do not find it difficult to get into mischief. Still, under proper supervision, three hours' relaxation between 9 A. M. and 9 P. M. does not seem to me an extravagant allowance for growing lads.

I have referred to the encroachment of book-work on play-hours. Having taken great pains to get at this point in various schools, my conclusion is that, what with back lessons, impositions, and extra subjects, this encroachment becomes in many instances a serious burden. I have been puzzled at first to explain the ill health of some boys when I examined the time-table, and did not succeed in explaining the mystery till I discovered how much of the play-time was really spent by them in work. This is, no doubt, often the fault of the boy, who has not properly learned his lessons, and has to relearn them when he might have been at play. It would be well, however, if the masters would consider whether they do not sometimes, by the amount of work set the boys, render it difficult to those who have only average ability to do all that is expected of them without encroaching on the time of recreation.

In one school I find, as might be expected, that some boys do and some do not complain of the pressure put upon them out of school. I believe this arises in these instances from a difference in facility of learning and not indisposition to work. One pupil, who has left school, and loyally observes, in writing to me, "I feel bound to stand up for a system to which I owe so much," reluctantly admits that the number of lines of poetry and prose which have to be committed to memory is quite unreasonable. The danger of overtasking the brain is here, I believe, by no means an imaginary one. The repetition, which goes on gradually accumulating during the term, of some sixteen or eighteen lines of Greek or Latin verse at each lesson, becomes at last a heavy load for the memory; and my informant adds, "At the end of term I have known over one thousand lines demanded, with only a day's time to look them over in, the usual amount being four hundred to seven hundred lines in the upper forms on the classical side." Another scholar, in a different school, writes: "I have never known more than thirty new lines of Greek or Latin set for one lesson. No time is specified for learning the lines, but they have always to be done between evening school one day and morning school the next, unless the master chooses to set the lesson before." Here we see how important it is, if we wish to estimate the real amount of brain activity in the twenty-four hours, to inquire into the out-of-school tasks, for while, when looking only at the time-table, we may picture to ourselves a boy comfortably asleep in his bed, he may in reality be engaged in hammering his Greek lines into his brain. The same pupil writes: "The extreme variableness of the work makes it not improbable that some boys (as I did myself at one time) have to work the whole day without intermission (i. e., of course, during whole school-days), and many, especially in winter, work all the evening, from a quarter-past six to ten o'clock, with only an interval for supper."

A teacher of languages in England complains that his son, who is at the grammar-school at ——, has lessons given him to learn which occupy him until ten at night. A gentleman in Devonshire informs me that his boy brings home from school tasks which frequently keep him up till midnight. At a high-school in a large town, I know that some of the pupils have suffered from overwork; two in one family have recently died from "brain-fever," due, it is considered by a medical man, to this cause. Dr. Fayette Taylor, of New York, has drawn a graphic picture of what the Americans are suffering from intemperance in study, and we should do well to take warning from it. "Girls arrive at twelve or fourteen, and, at the threshold of the most important period of existence, utterly unfitted for passing through it. Excitable, with wide-open eyes and ears for every sight and sound which can excite feeling, vapid and intense in mental activity, with thin limbs, narrow chest, and ungainly back, we meet these twelve-year-old products of civilization going to school with an average of thirteen books under their feeble arms—for I have found by actual count that thirteen is the average number of studies which they 'take' nowadays."

I may here record the hours of a school for girls, which appear to me to exceed what is wholesome, and to be well calculated to lessen their mental elasticity and interfere with their healthy development. These girls rise at 6.25; prayers are at seven, and breakfast at a quarter to eight. Their studies commence at a quarter-past eight and last till twelve, with a break of a quarter of an hour; then dinner, during which silence is enjoined and a book read aloud; then an hour's recreation is allowed. Needlework and school-work follow for two hours; half an hour's recreation succeeds, and then come two hours and a half of study and instruction of various kinds. The next meal after the twelve-o'clock dinner is at half-past six, and this is the last. It is succeeded by half an hour's recreation, and this by half an hour's study. Prayers end the day at half-past eight. Here we have nine and a half hours (including religious exercises) of sedentary occupation, and only two hours and a quarter for recreation and one hour and a half for meals. I think we shall be agreed that a little less school and a little more play would be desirable, and that there need be no cause for surprise to find that many of the scholars suffer from headaches, anæmia, arrested development, and various manifestations of exhausted nerve-force.

Then there are the school *examinations*, and these, I am satisfied, require great care, while most useful means of rendering the knowledge acquired by the pupils definite. A former pupil in the sixth form writes: "With regard to examinations, an hour's examination in each subject was supposed to take place once a month. At the end of the term we had from a week to a fortnight's examination in all subjects prepared during the term. *Making fellows learn up all their repetition at end of term, and keeping them back if they fail to say it, I consider a piece of barbarism.*" I believe that in many schools the examinations at the end of the term embrace so many subjects, and lead to so much cramming of minute details, that from these causes and the spirit of emulation excited the brain is often unduly stimulated, and a state of commotion induced which is highly undesirable. It is true that a long holiday then comes to the scholar's relief, but even an extremely long holiday does not render it safe to undergo extremely severe mental strain. I suspect that with some it is thought to do so, but it is most important that this error should be clearly pointed out. A schoolmaster recently remarked to me that a boy would sometimes answer the first paper in the examination *very well*, the next *not so well*, and by the time he was engaged in the last questions he would be *muddled and stupid*. "He seemed to have got to the end of his brain," as the master aptly expressed it.

I wish now to refer to the present system of *medical* education. How can it be otherwise than injurious when we consider that during recent years the amount of knowledge which it is necessary to master has prodigiously increased in every department, while the length of time in which to acquire it remains the same?

In regard to some examinations, a tremendous burden is laid upon the memory. There is a long period of strain, the climax of which is reached when the period of examination arrives, during which the student's mind has to hold in solution the details of knowledge on many subjects. It is often a solution saturated with minute facts and figures, many of which are of no permanent use, and indeed can not be remembered any longer. The mind is cramped and narrowed by this mischievous cramming, as must necessarily happen when the issue of an examination is made largely to hang upon a retentive memory.

While no one proposes to go back to the old system of medical education, it may well be doubted whether the character of these examinations is calculated to develop the best practitioners or physicians, loading the memory, as they too often do, at the expense of breadth, depth, and originality. The lectures delivered in the medical schools are, of course, influenced by the examinations, and is it not notorious that these now give so many different hypotheses and enter so much into detail that the student is often perplexed? And (if report may be credited) the lecturer himself sometimes becomes perplexed also.

Too rapid an acquisition of knowledge—the attempt to master too many subjects—is a part of that Jehu speed at which we are now driving, whether in business or science. Knowledge so gained "proves but of bad nourishment in the concoction, as it was heedless in the devouring." So said Milton in his day. What would he have said now? Competition is not confined to trade. Our examination boards have, in truth, not escaped from its influence. It is melancholy to see that the errors we deplore are perpetrated by men whose knowledge of physiological laws ought to have prevented them from pursuing so disastrous a course. Professor Humphrey has protested in terms of strong disapproval against the system of examinations now too generally pursued, and we of all men ought to join our voice with his in the endeavor to stem the current of this excessive and indiscriminate brain-stuffing. "Knowledge grows, but man stands still; that is to say, the intellect and powers of man are no greater now than they were in any of the known past ages; in the days, for instance, of Homer or of Plato, of Confucius, of Buddha, or of Moses; no more powerful to mold the material at hand, whereas the material has vastly increased. . . . Had Hunter been trained upon the present system, had he been weighed down by tightly compressed facts when a student, and subsequently, by out-patient-seeing, on the one hand, and pupil-cramming on the other, it is scarcely to be supposed that even his mind could have burst the iron fetters, and could have regained its elasticity and love of work, or that even he could have found time for those reflections which gave such impulse to the science and practice of surgery." ("Hunterian Oration," February, 1879.) One source of mischief lies in the fact that an examiner constantly forgets that the department in which he examines is only one of many, and hence he requires a degree of perfection which is simply absurd—one which, however, suited to honors, is totally unreasonable in a pass examination; and it must be remembered that the severity of an examination can not be gauged by a reference to the questions which happen to be asked at a particular examination. The student has to prepare himself for all possible questions, ranging over very wide areas of knowledge, and involving an acquaintance with a multitude of speculations put forth by Continental as well as English writers. Hence it is not surprising if, in the anxiety to pass the ordeal, success is too often won at the risk of prolonged mental prostration. Failure, on the other hand, involves, besides this, the dangers arising from disappointment and chagrin.

I should not have thought it at all probable, when I commenced this paper, that before I concluded it I should have listened to far stronger remarks than any I have indulged in, in an assembly of medical teachers and practitioners in London at a meeting of the Metropolitan branch of this Association, under the presidency of Dr. Andrew Clark. On this occasion, Mr. Huxley said that to expect students to pass an examination in the subjects on which they are now examined, after only four years' study, was little short of "criminal." He characterized the attempt "to cram the student with all these subjects as utterly preposterous. The amount of work expected is simply gigantic." Mr. Hutchinson said: "The best memories stagger under the present load. . . . That after four years' study a student can be expected to bear his subjects in mind is simply an *absurdity*."

But it is time to ask, What is the remedy for these evils?

First of all it is necessary to make them widely known. Educators and examiners must at least have no chance of sinning from ignorance, although, as I have said, some who know most of the laws of physical and mental health are the chief culprits. It must be insisted that they are oftentimes putting too heavy a weight upon the camel's back, and it is for them in the first instance to consider in what way they can best diminish the tension, and, as regards medical education, rearrange the curriculum. What I complain of is that at the present moment the tendency in certain quarters is to render this curriculum, and consequently the examinations, harder and harder, more and more unpractical; so that many can feelingly unite with the Earl of Ellesmere, who said to a friend, shortly before his death, that he was not sorry to go. The world was clearly becoming very disagreeable; everybody was going to examine everybody, and he was sure *he* should be plucked!

In the second place there must either be a change in the character of medical examinations, or the period of time occupied in study must be extended. I believe that the first is absolutely necessary, and that the second is in any case highly desirable. As regards the change in the character of the examinations, it should be in the direction of lessening the demands made upon the memory; and, as regards length of time, I think a year more than is now required would be a great advantage. It would also be an immense gain to the student if, while he is engaged in hospital-work, he should have no examinations hanging over him, except "medicine" or "surgery." This means the subdivision of medical examinations.

Mr. Hutchinson proposes that students should be thoroughly examined during their curriculum (by hospital teachers or traveling examiners) on the various subjects, and bring up certificates of proficiency to the Examining Boards. These would accept the certificates as proofs of competency in details, and would give a good, general, practical examination before granting a diploma. If this course be adopted, and is not overdone, it will certainly be an immense improvement on the present system, and would prevent students leaving too much of their work undone till the last year.

Thirdly, it seems to me of great importance that the number of subjects examined upon at the same time should, in some instances, be reduced. The original idea of the London University in arranging the subjects for the examination of M. D. was excellent—namely, to spread them over a sufficient number of years and to present them successively in a natural order of gradation. But, now that the mass of knowledge demanded has so vastly increased, this division of labor only partially meets the difficulty of the student, for he has now to be prepared to answer questions in the course of a few days which demand a painful retention of an enormous number of facts in the memory. Some relief would be obtained here by a longer interval being allowed between the days of examination on different subjects.

In the recent discussion on medical education to which I have referred, Mr. Huxley urged that one mode of relieving the present strain would be to make the preliminary subjects (in an elementary form) necessary parts of school education. Thus a boy ought to know a bone or a muscle when he sees it. My fear is that by so doing we should intensify the labors of school-work, unless it is on the distinct understanding that these subjects are not added to, but take the place of, some which are now taught at school; otherwise it is merely cutting off one end of the plank and fastening it on to the other. Mr. Huxley's proposition assumes, of course, that it is well to introduce these studies into schools as a part of the education of all, whether intended for the medical profession or not.

Fourthly, whatever course is adopted, it is, I would hope, unnecessary to say that the crotchets of individual examiners should not tinge the questions, or rather the judgment formed of the answers. If the questions which are now asked are not too severe when taken alone, they are regarded by many competent judges as frequently too severe when taken in combination with the other subjects examined upon, and also that they are sometimes calculated to puzzle the student, from the form in which they are worded. Not long ago an examiner at the London University, speaking to another examiner, boasted of the puzzling questions he had been ingenious enough to ask, whereupon the other replied, to my great satisfaction, "You should try and find out *how much*, not how little, the students know." I should have no fear of the questions being unreasonable when put by a wise, common-sense Professor like this, whereas some learned men expect a student to reach in a few months the level of their own mature knowledge.

I would adopt the language, once more, of Professor Humphrey, and say: "With Democritus 'we should strive not after fullness of knowledge, but fullness of understanding'; that is, that we should strive for good, clear, solid, intelligent, producible, and available knowledge, of the kind that will be useful in after-life; not so much the *re-*

finements of chemistry, anatomy, and physiology, which stupefy and then pass away like chaff before the wind, but the essential fundamental facts and principle, welded together, and so woven into the student's mind that he can hold them firmly and wield them effectually; and that he is conscious of them, not as the goods of other men, or as dogmas which he has because they were imposed upon him, but as his own possession, of which he appreciates the value because he knows how to use them."

In conclusion, I would express the hope that the expression of opinion in the Psychological Section of this Association will strengthen the hands of the Metropolitan branch, which has taken up this question with much earnestness, and, although starting from a different standpoint from my own, has been equally impressed with the evils attending the present system of medical education. *I* am moved by the conviction that its influence upon the mind is injurious; *they* by the fear that it fails to produce the best men, and the belief that it is altogether unreasonable.—*Journal of Mental Science.*

WATER AS FUEL.

By WM. C. CONANT.

THE satyr in the fable was not more scandalized at the man who blew hot and cold with the same breath, to warm his fingers and to cool his porridge, than the old acquaintances of water as the natural cooler and refresher of the world have been to find it artificially asserted as supreme in the opposite office of heating. It may well seem the extreme of paradox that the same element which tempers the excess of both solar and animal heat should also become the great source of supply for their deficiency. And yet why should not the universal absorbent of this power be made to restore it? We have long known that water is but the fuel of the universe as transformed by combustion—a cold residual of a cosmic conflagration that still rages in the central mass of our system, and has hardly subsided as yet in its principal fragments.

Hydrogen—the "water-parent," or distinctive element of water, as its name imports—may be regarded, metaphorically at least, as a metal, which no degree of cold in nature, or where life exists, can reduce to the density of a liquid. It oxidizes so eagerly, and in such infinite abundance, as to be the only combustible comparatively worth mentioning: nowhere to be found, in fact, but in vehement combustion or in its cold result as water, unless where locked in the embrace of its secondary affinity, carbon, in the various oily products of organic life. In the latter condition—the hydrocarbons—hydrogen is protected from the all-devourer, oxygen, and enters into innumerable uses. As the inflammable ingredient of wood, of bituminous coal, of petroleum and other vegetable and animal oils, we have it sealed up by Providence, as it were, for a temporary and portable fuel, pending the full development of man's proper authority over the elements—temporary, for it has long been a source of anxiety to economists that the resources of forests and coal-fields are so finite and their prospect of exhaustion so definite. It is evident from the coal "measures" that man was never intended to remain dependent on what he could pick up ready made for his needs, in respect of fuel any more than of other things; albeit this provisional supply for his infancy was made ample and accessible above all others. Even the novel service of carbon (which we shall observe more particularly further on) in smelting hydrogen "ore" from the vast mines of lake and ocean—as it does also the oxides of other metals from telluric mines—bids fair to be divided with some more unlimited artificial agency in due time. To the present time carbon, diffused and heated to intense brilliancy in burning hydrogen, has been our only artificial illuminant on a practical scale. And yet it now seems likely enough to be superseded in this office also, at no distant day, by fixed illuminators excited by the combustion of hydrogen or the force of electricity.

The better hydrogen becomes known, therefore, the more interesting and important to us it is found beyond all other elements, oxygen scarce excepted. To all the vital and delightful uses of water, as we have seen, it adds also those of light and heat. For, although scarcely luminous in itself, hydrogen is a principal source of the heat which makes other substances luminous, and is thus a chief condition of illumination. Terrestrial flame is generally hydrogen gas in the act of combustion, colored and made brilliant with white-hot carbon also oxidizing. Carbon may therefore be called a diffused illuminant, and the only one of any importance available at a living temperature, although in the terrific conflagration of the sun all things, even the most stable, are diffused in gaseous incandescence. The more stable substances that maintain their solid form in the comparatively moderate terrestrial heat of burning hydrogen until they become intensely bright are called fixed illuminators. Progressive examples may be cited: in platinum, the most non-fusible of metals, which endures and emits in light the intensity of hydrogen burning in air; and in lime, a still more refractory substance, which glows with dazzling power in the fierce combustion of hydrogen with pure oxygen, commonly known under the name of calcium light.

If Mr. Lockyer should succeed in verifying his startling hypothesis that hydrogen may be in fact the *only* thing in the material universe—not the water-parent only, but the all-parent—our present celebration of this great element would prove neither inopportune nor inordinate!

After all that has been said of it, the nineteenth century furnishes an ever-fresh and amazing retrospect. Within the memory of the living these now common facts—too vast and sublime, however, to be called familiar—were hid, with the great bulk of modern science, indeed, from the sages of the world. Oxygen had but just been discovered, a hundred years ago; hydrogen was unknown; water was supposed to be an elementary substance; fire and flame were mysteries; what the sun might be, and the nature of its light and heat, nobody could guess. After hydrogen had been found elsewhere, it was discovered (in 1781) that water is the result of its combustion with oxygen, and in 1805 that two parts in three of the vast volume of that element pervading and covering the earth are contributed by this ethereal ingredient. Several ways to dissociate the two gases were found, but the common and practical method was and is the contact of steam with red-hot carbon. This, in the absence of free oxygen, results in a transfer of the water oxygen to the carbon fuel in combustion, leaving the water hydrogen free. Red-hot iron answers a similar purpose, forming an oxide of iron (rust) in place of carbonic acid; but the consumption of so valuable an article as iron in the process has hitherto excluded this method from practical use, although there is now some prospect that by deoxidizing the iron-rust it may become available over and over for the elimination of hydrogen at a minimum of cost.

Until a recent date it has been quite generally taken for granted that, since to separate the two gases of water must cost as much heat as they will evolve by reuniting in combustion, there could be no possible profit in forcing the separation for the sake of fuel. Hence, the application of water hydrogen to practical purposes has been regarded as visionary. But there are some considerations on the other side also that seem to have been overlooked. The unavoidable waste in burning solid fuel has been found to range from fifty per cent. as a minimum in the arts up to ninety-five per cent. as a common proportion in stoves, and thus to exceed by several volumes the whole cost of obtaining from water a gaseous fuel which can be used with but insignificant waste. Besides this, the doubted possibility of economizing the carbonic acid has also been realized, and that hitherto worthless incumbrance has been incidentally recarbonized in the process and utilized as carbonic oxide, to an economic success. Direct economies in the process have also been achieved, preventing great waste of heat in various ways, including that of a large amount hitherto lost in cooling off the finished gas. These recent—and American—improvements have suddenly given a practical character to the manufacture of water-gas, and a practical purpose to the elucidation of the subject.

Notwithstanding an unbroken succession of failures in the economic sense for more than half a century, the unlimited and ubiquitous stores of hydrogen "ore" have mightily stimulated inventors to the task of extracting treasure from these mines of fuel. Few objects have engaged the ingenuity of the nineteenth century in so extensive and indefatigable researches, with (prior to 1874) so little result. Scores of patents have been taken out, mostly by French and English inventors, for different methods of obtaining and employing water hydrogen for illuminating purposes; and a number of minor towns and manufactories in Europe have been and are to this day supplied, by as many different methods, with water-gas. Want of space forbids us to review these methods as to their successes or defects. The common inherent obstacle to their progress is the lack of a sufficient margin of economy to overcome the immense vested interests that oppose any departure from the use of bituminous coal. Such a margin can never be attained under the waste inseparable from the use of retorts, heated externally, to which all the European inventors have adhered. One of the best of their efforts is that of Tessié du Motay, adopted and modified by the Municipal Gaslight Company of New York, and lately purchased of the latter for the down-town district held by the old New York Gaslight Company. Its advantages, however, are subjected to an obvious drawback, in addition to others before mentioned, in a necessity for reheating the gas to give it a fixed character.

In short, the test of successful propagation had never been met by any system, in any measure, on either side the Atlantic, until the introduction of the recent American process, which has proved both in theory and practice a consummation and a contrast to the whole previous history of invention in its line.

But illuminating gas, and the struggles of half a century to cheapen it by water hydrogen, have interested us but incidentally as leading up to a later and still more important result—the practical availability of water-gas as *fuel*. In fact, the rapid progress and generally anticipated success of the electric light have given pause to all present enterprise in illuminating gas. New movements are almost suspended, and shares in the oldest and most profitable works are no longer the favorite investment. A probability has suddenly appeared that the uncounted millions of irrecoverable capital invested in gas mains, pipes, holders, etc., may eventually find no other employment but to supply fuel-gas to the households that have hitherto depended on them for light. In view of such a prospect the feeling of the gas interest toward water hydrogen must become seriously modified. The lately dreaded process begins to look like a friend in need—the only hope of rescuing much capital from total loss in the not improbable event of a satisfactory and economical diffusion of the too concentrated electric light.

Our remaining space, then, will be dedicated mainly to fuel-gas, and the process as modified for that product; first, briefly describing the apparatus, and the distinctive processes for producing by it illuminating and non-illuminating or fuel-gas.

Disregarding details, the apparatus consists, substantially, of a strong brick cupola-furnace with an iron shell, as gas-generator; this connected by a flue with a secondary chamber as superheater, filled with loose fire-brick nearly to the top. The gases generated from an anthracite fire in the furnace are driven by the air-blast through the connecting flue into the secondary or superheating chamber, at the bottom; here they meet a second air-blast, which urges them to a blaze of intense and complete combustion; and in this superheated condition they are forced up through the labyrinthine interstices of the fire-brick with which the interior of the chamber is piled.

So effective are these simple arrangements that, in the few minutes required to kindle the mass of coals in the furnace to a cherry-red, the mass of fire-brick in the superheater becomes white-hot and ready for use. This result is the work of carbonic oxide and other products of imperfect combustion usually passed off in the smoke of our domestic chimneys, and finely illustrates the main point of advantage in gaseous fuel—its more complete utilization. If any of us could see the regular gaseous waste from our kitchen-stoves kindled up in the chimney to a pitch of heat sufficient to melt iron there, it would be a convincing proof of the estimated loss of ninety-five per cent. of our fuel, and would resemble faintly what is done outside the fire-chamber of the Lowe or Strong furnace, and in what answers to the chimneys of our dwellings.

At this point (to return) the air-blast is shut off; the outlet of the chimney is tightly closed; and a cock is turned which lets a jet of steam from a boiler into the bottom of the furnace and up through the mass of glowing coals. Instantly the process of combustion ceases (as between the coal and atmospheric oxygen), and the generation of water-gas begins; in other words, the coal now takes oxygen in combustion from the steam which has been substituted for air, and leaves the water hydrogen free. The hydrogen, lightest and thinnest of gases, which had been pent in the form and consistency of water, is now itself again, expanding to vast volume, like the ethereal *génie* let out of the casket by the Arabian fisherman, and ready to do the bidding of its liberator. At the same time a valve is opened in the upper part of the furnace, which lets fall a steady shower of crude petroleum on the fire. The pungent and fuliginous vapor in which the oil rebounds from the burning coals is a heavy solution, so to speak, of carbon in hydrogen. Into this thick mixture the free water hydrogen, rushing up from the decomposition of steam below, freely enters, diluting it to proper proportions for burning completely and cleanly, without smoke, in the open air. Another ingredient, rolling up from the fiery laboratory, also mingles in the tempest of hot gases, and still further heightens the calorific and consuming powers of the compound. This is carbonic oxide, the great value of which, either in a fuel or illuminating gas, and its spontaneous development in place of incombustible carbonic acid, are among the advantages which have given to the American method the first decisive success in supplying the public with water-gas.

The oxygen of the steam, as we have seen, on entering the burning coals at the bottom of the furnace, instantly unites in full proportions with the first carbon it encounters, forming carbonic acid. But this carbonic acid, as fast as formed, is driven upward through the fire, and, before it reaches the other gases, its greedy oxygen has gorged itself with a double portion of carbon from the coals, and it is now carbonic oxide—a gas rich with carbon, which is ready to unite in combustion with a further proportion of oxygen wherever it can find it. But it finds no oxygen among the gases to which it is introduced, for the air-blast was shut off when the steam was let on. Consequently, it enters into the compound, and remains as a third combustible.

Meanwhile, the mingled gases are rushing from the furnace, under high pressure, through the flue into the secondary chamber or superheater, and up through the white-hot mass of fire-brick which it contains. Struggling through the hot crevices in attenuated streams, the gases reach a temperature of nearly 2,000°, at which all the elements present are perfectly released and enabled to form such recombinations as their stronger affinities dictate. As the oxygen here finds itself in a hopeless minority, and remains dominated by the superabundant carbon with which it is associated in carbonic oxide, there is no rival to forbid the bans between the king and queen of combustibles—Hydrogen and Carbon.

The charge of coal in the generator makes from five to seven thousand cubic feet of gas : the process of generation taking thirty minutes. The steam is then shut off, and the generation of gas ceases. The lid is raised, the air blast readmitted, and ordinary combustion is resumed. The stoker approaches the fiery pit on a floor level with its mouth and pours in another charge—a barrel of anthracite—fastens down the lid, and for fifteen or twenty minutes the air-blast again urges combustion until the mass in the generator is of a lively red, and the fire-bricks in the superheater are once more white-hot for a second run of gas. At every sixth charge the ashes are raked out, and two barrels of coal, instead of one, are put on.

When the eight sets of apparatus in the Baltimore works are in operation, the actual product per twenty-four hours, with all delays, amounts not unusually to 600,000 cubic feet ; and it has been practically demonstrated that 1,000,000 cubic feet could be made by the same apparatus in the same time. Provision is also made for as many more sets of apparatus as may be required by the future extension of the business.

We are now prepared to understand clearly the later and more important process of making pure *fuel*-gas ; which commends itself to us as the next great economic stride of the arts, and therefore as the true " objective point " of this article.

The first stage of the process invented by Mr. Strong is so nearly the same with that already described that a repetition is unnecessary, the furnace being fired up until the loose brick contents of the secondary chamber or superheater are at a white-heat, when, as before, gas-making is commenced. But here the current of the process, so to speak, is reversed. Instead of letting the jet of steam in at the bottom of the furnace, we let on steam at the other end of the system, i. e., at the top of the superheater, and pass it directly downward through the mass of white-hot fire-brick. This raises the steam to a perfectly invisible gas, hotter than devouring flame, as it rushes from the superheater, through an extra flue, into the upper part of the furnace. There it meets a shower of anthracite coal-dust instead of petroleum, sifted down into the furnace from above, and literally burns it up with intense combustion—precisely as coal-dust would be devoured in the fierce flame of the blast-furnace seven times heated, except that the oxygen of this combustion is supplied entirely by a steam- instead of an air-blast. In other words, the steam furnishes both heat and oxygen for the instant conversion of the coal-dust to carbonic acid, with the consequent release of its own prodigious volume of hydrogen. Under their own increased pressure, the gases continue without pausing, down though the mass of glowing coals. In making this passage, the carbonic acid takes up a double portion of carbon from the hot coals and becomes carbonic oxide—the powerful heating gas so often seen burning in a lambent violet flame on the surface of anthracite fires when the air is let in on them. As there is no access of atmospheric oxygen to the furnace, there is no opportunity for the combustion either of this gas or of the freed hydrogen, and accordingly both pass out together at the bottom of the furnace, through a pipe which conducts to the gas-holder.

The product of this process, before purification, has been rigorously analyzed by the several methods, by Professor Gideon E. Moore, Ph. D., and proves to be 52·76 per cent. pure hydrogen, 35·88 per cent. carbonic oxide, and 4·11 per cent. marsh-gas, making nearly ninety-three per cent. of the whole volume in these powerful calorific agents, leaving only six to seven per cent. of incombustible waste (carbonic acid and nitrogen). Wurtz also gives substantially the same proportions, in Johnson's "Cyclopædia."

The purity of this fuel is a consideration nearly sufficient of itself to revolutionize the manufacture of iron, and especially of steel, for which, in its perfection, few if any mineral coals are sufficiently free from such troublesome ingredients as sulphur, phosphorus, etc.; but of this further on.

With respect to comparative calorific values, Professor Moore's report shows, by rigorous calculation, that the Strong fuel-gas will produce 2·78 times the practical effect of the amount of coal consumed in its manufacture, supposing the same coal were burned directly by the most perfect methods of combustion and utilization known in the arts. But in these methods, according to standard authorities, at least five times as much of the fuel is utilized as in the average of stoves. The practical heating value of our domestic fuel may therefore be multiplied fourteen times ($5 \times 2{\cdot}78$) by using it to make water-gas.

But, again, the material actually used at Mount Vernon in making the water-gas analyzed by Professor Moore, instead of being our domestic fuel, worth from four to six dollars per ton in New York, was mostly nothing but waste coal-dust, dug up from an old "fill," where it had been used in grading the street; and when the gas product itself is reapplied to making and superheating the steam—as, of course, it will be—the use of merchantable coal may be entirely dispensed with. Of the refuse dust we have literal mountains accumulated at our coal-mines and depots, as well as constant deposits at every coal-yard, which the proprietors would now be glad to have taken away gratis. Making ample allowance for the expense of appropriating these supplies of coal-dust, and allowing only the lowest price of chestnut coal for the article consumed in our stoves and furnaces, we can multiply the present equivalent for our domestic coal bill at least three times more by the gas process—less the charges for invention and organization, capital and interest, manufacturing management, and distribution. The proprietors propose to have the fuel-gas delivered at fifty cents per one thousand feet, with a good margin of profit, as it can even now be made for ten cents. Compared with illuminating coal-gas by volume, its heating power is found to be about as three to five. Hence, coal-gas at eighty-five cents would be as cheap fuel as water-gas at fifty. But, in point of profit to the maker, the difference at these prices would be greatly in favor of the water-gas; while, in another controlling matter, on the side of the consumer, it is not *malapropos* to say that comparisons are "odorous." The mysterious but not agreeable smell raised by a coal-gas jet of the best air-mixing or total-combustion burner, when impinging on the surface of any cooking utensil (thought by Professor Wurtz to arise perhaps from a synthetic re-formation of gas) is a serious objection to coal-gas cooking, from which water-gas is absolutely free. Its combustion is perfect, without air-mixture, and without smell, "synthetic" or whatever. So far as the hydrogen is concerned, the product of combustion is pure aqueous vapor, in a quantity not likely to overcharge with moisture the atmosphere of the house. The other principal ingredient, thirty-six per cent. of carbonic oxide, becomes, of course, carbonic acid in burning, and must be conducted away.

Using a Goodwin's gas-stove to its full capacity at once as baker, broiler, and boiler—simultaneously baking bread and potatoes, boiling other vegetables and coffee, and broiling steaks and chops, sufficient for a dinner-party of "experts"—Mr. Strong found the time thirty minutes, and the consumption of gas thirty-two and a half feet, or sixty-five per hour. This (at fifty cents per one thousand feet) was three and a quarter cents per hour for the full running of the cooking apparatus or one and five eighths cent for cooking the entire dinner.

Turning from the domestic to the business arts, we encounter a prodigious revolution on the threshold with the incoming fuel. The gas-engine already referred to, as recently improved and extensively introduced under the German patents of Otto, supplants the steam-engine completely, on the small scale, even at the present high cost of coal-gas, and with certain other drawbacks peculiar to that somewhat tarry article. It is already available up to thirty horse-power, and at fifteen and under it is universally found a much cheaper source of power than steam, and with gas of five times the cost and much less adaptability than the American water-gas. Thousands of these engines are used in England, and in London it is expected that steam-boilers with their smoke and danger will ere long be prohibited where the gas-engine is available. The "silent" gas-engines are also selling rapidly in America on the lines of rural and minor manufactures. What new stride this important substitution may take with gas at fifty cents and free of tarry ingredients, one hardly dares conjecture. But its absolute safety, automatic operation, and slight displacement, open to the gas-engine a vast sphere of common and household uses for which no motor had before been adapted. On the large scale, moreover, we may perhaps live to see such things as gas-locomotives, unburdened with coal or water, rid of their boilers, their annoying smoke, and their destructive sparks, and satisfied with picking up at intervals a plate-iron tender-car full of compressed water-gas.

In hope of closing with a sustained interest, the first actual and one of the greatest possible applications of the new gas-fuel has been left to be last mentioned—that of the manufacture of iron and steel, lately commenced in Sweden, under the American patents and the personal superintendence of a gentleman to whose inexhaustible energy and tact the American water-gas is largely indebted for its difficult yet brilliant progress—Mr. George S. Dwight, of Montclair, New Jersey.

Siemens's gas—a product saved from the combustion of coal in a furnace invented by that distinguished metallurgist—has long been used with admitted advantage in various branches of iron-working. With this well-known and standard form of gaseous fuel, Professor Moore's report, already quoted, minutely compares the American water-gas, showing that the former is many times more expensive and less efficient than the latter. In fact, water-gas made under all the old disadvantages of method is said to have been in use twenty years ago at the Oldbury furnaces near Birmingham, England, and was introduced nearly as long ago in the Yorkshire blast-furnaces. It has also been used with marked preference in France, by workers in the finer metals particularly. Of the American water-gas, Dr. Moore says that its special advantages in metallurgy are, besides its great economy in cost and consumption, the high and easily regulated temperature it affords beyond all other fuel, and the relatively small volume of products of combustion evolved—being, in short, the most concentrated form of gaseous fuel hitherto available for such purposes. To which he might have added (if he had not been at the moment confining his comparisons to gases) that its freedom from the impurities rife in mineral coals, and that greatly restrict the supply of iron fit for refining, seems alone sufficient to insure its substitution for all other fuel in the manufacture of iron and steel.

That Sweden has been first to move in this direction was natural, from peculiar circumstances. This preëminence of "Swedes iron" has been sustained under a singular disadvantage as to fuel. The country is destitute of coal, and pays a monstrous tax on that grand factor of its leading industry in the expense of importing it from England. On the other hand, it possesses inexhaustible stores of peat, which is well adapted to the manufacture of water-gas by the American process, and will henceforward supply the Swedes with that perfected form of fuel at a cost that will seem to them as nothing.

The operations now going on in Stockholm under the superintendence of Mr. Dwight were initiated by a semi-official body styled the *Jernkontoret* (or Metallurgical Association), which, under the patronage of the Government, pursues whatever investigations and experiments promise advantage to the grand interest of that country. Its voluminous published researches and reports are of standard authority in metallurgy all over the world. Water-gas making was commenced with American apparatus erected in the Atlas Works, Stockholm, in 1879, and the product applied to the treatment of iron-ores and the manufacture of steel. An official certificate of unqualified strength has been published under the signatures of leading Swedish and Russian metallurgists, and new works on a practical scale are now being established. The subject excited extraordinary interest throughout the intelligent classes of the nation. Preparations were also made to conduct the gas into various establishments and mansions for the purposes of warming and cooking. Orders have reached New York for fuel-gas works of the same kind in St. Petersburg, Russia, and preparations were making at the latest advices for similar movements in Austria and Bohemia, as well as to press forward organizations for the supply of American cities with both domestic fuel and manufacturing power in this form. The introduction of a ubiquitous motor (for the Otto silent gas-engine) as handy, cheap, and common as the ordinary gaslight, will mark a new era in industry, and prove an important new factor in political economy.

THE EARLY FREE SCHOOLS OF AMERICA.

By ALICE HYNEMAN RHINE.

WITH the discovery of America, the founding of colonies in the New World relieved the Old of so much surplus population as gave the people of both hemispheres many new chances in life. The advantages of education, meager as was the information given by the schools, inspired men with a desire for larger liberty than the old monarchical governments were either able or willing to give. The men that emigrated to America were of the liberty-loving type. Unfortunately, however, it was love of liberty for *themselves*, not for others. The Puritan fathers, far from being the lofty minded men historians have fondly painted, were bigots, without learning or desire for anything beyond worshiping their own idea of God in their own peculiar fashion. In some respects it was the misfortune of America that these men were the inaugurators of her religious and educational codes. An opportunity so splendid had never been granted to humanity. America started into life with the civilization, the culture, the experience of past ages as her teachers; she was enabled to take up at the last leaf the book of progress which had been commenced cycles before in India, Egypt, Chaldea, Greece, and Rome. The slow emergence from barbarism, the crude and cruel experiences of all other peoples, could have been remitted in her favor; like the fairy princess in the story of the "Forest of Lilacs," her teaching was proceeding while she slept. Had she been able, upon awakening, to make use of this culture—had her governors been men of liberal views and greater foresight—in America the "Utopia" of More might have become a possibility, and the "New Republic" of Plato a successful reality.

Instead of this enlarged freedom, the history of education in America is replete with theocratic superstitions. Theology interfered with the civil laws, and both Church and state hampered with their bonds the free development of education. Colleges were founded, not so much for the advancement of science as to provide learned ministers for ecclesiasticism. In the early colonial times, the Bible, Psalm-book, and Catechism comprised in great measure not only the school-books of the children but the family library. In 1720 we read that but one parish library could be chronicled in the colony of Virginia. This library consisted of three books—"The Singing Psalms," "The Whole Duty of Man," and "The Book of Homilies.

This dearth of reading matter, as might have been expected, resulted in making Biblical stories as familiar to the children of the colonists as the legendary tales of fairies and gnomes had been to the dwellers on the borders of the Rhine and Rhône. The dramatic tragedies of Daniel, Samson, Jonah, Jesus, the saints, and Christian martyrs, from being studied in school-hours and talked about at home, became things as real as the daily lives of the colonists.

The struggle for freedom, the importation of secular books, the introduction of printing-press and newspapers, diverted the minds of the people into broader and deeper channels. The men of liberal thought and culture who founded the Republic of the West, such as Jefferson and Madison, agitated the subject of the higher education of the people. It was particularly the desire of Jefferson to have crusades preached against the evils of ignorance, and to have laws established for informing and educating the common people.

"Free schools" had always been, and justly too, a favorite scheme among reformers for elevating the race. American statesmen and philanthropists put this plan in operation at an early period; it met, however, with but ill success at first, owing to the dearth of skillful teachers. One of the early writers says: "The business of instruction in preparatory schools was with few exceptions under the control of inadequate principles; in many instances the commonest business of life was abandoned on the demand for a teacher; and the responsible duties of an intellectual guide undertaken by individuals whose chief recommendation was their dexterity with the awl and hammer."

It was not until over thirty years after the close of the war of 1776 that a regular system of schools at the public expense was established. New England boasted with pride of being the first in education, as she had been in war. Her example was closely followed by the other States. In New York, in 1805, many gentlemen of prominence associated for the purpose of establishing a free school in New York City for the education of the children of persons in indigent circumstances, and who did not belong to, or were not provided for by, any religious society.

These public-spirited gentlemen presented a memorial to the Legislature, setting forth the benefits that would result to society from educating such children, and that it would enable them more effectually to accomplish the objects of their institution if the schools were incorporated. The bill of incorporation was passed April 9, 1805.

This was the nucleus from which the present system of public schools started into existence. Later on, in the year 1808, we find from annual printed reports that two free schools were opened and were in working order.

One of these schools was situated on a large lot of ground in Chatham Street, on which was an arsenal. It was presented by the corporation to the Free School Society of New York, on condition of that organization gratuitously educating the almshouse children. In 1809 the building was ready for occupation; it was a brick edifice one hundred and twenty feet in length and forty feet in width, capable of accommodating in one room five hundred children. In the lower story was another room which would contain one hundred and fifty scholars, with other apartments for the teachers and the meetings of the trustees.

The other school was built in Henry Street, on ground donated by Colonel Henry Rutgers in 1806; this building was not completed, however, until 1811, and was then known as School No. 2. In appearance it was the same as the one in Chatham Street, but was not quite so large, having accommodations in both floors for about four hundred and fifty pupils. About four hundred children were admitted into the two schools; the annual expense of each was, as near as could be estimated, three dollars per head.

It was the intention of the founders of these schools—among whom the names of De Witt Clinton, Ferdinand de Peyster, John Murray, and Leonard Bleecker stand prominent as officers—to avoid the teachings of any religious society; but there were among the people many who thought that sufficient care was not being bestowed upon religious instruction: to please these malcontents the literary studies of the pupils were suspended one afternoon in every week, and an association of fifty ladies of "distinguished consideration in society" met on this day and examined the children in their respective catechisms. The parents and guardians designated the denomination in the tenets of which they wished their children educated.

Every authority acquainted with these schools expressed satisfaction at the literary improvement of the children. The system employed was that of Mr. Joseph Lancaster, of London, and consisted of class-teaching in reading, writing, and arithmetic. The employment of the scholars, as made up from the printed reports, may be curious reading to many in this era of multitudinous studies.

Children were first taught to form letters in sand; then advanced to monosyllabic reading on boards; from reading on boards to Murray's first book; from Murray's first book to writing on slates; from writing on slates to writing on paper—to reading in the Bible—to addition and subtraction—to multiplication and division—to the compounds of the first rules—to reduction—to the rule of three.

To read, write, and know arithmetic in its first branches correctly, was the extent of the educational advantages which the founders of the free-school system deemed necessary for the accomplishment of their purposes. When proficient in these studies the scholars were apprenticed to some useful trade or given a profession, if the inclination and genius of the graduate seemed sufficient to warrant the inincreased outlay.

This system was better than any that had preceded it. Under its influence the blind obedience that had marked the lower orders of Egypt, the Asiatic and Roman proletariats, and the villeins of the feudal period, passed away. Education, which in the past had been solely aristocratic and theological in its character, became democratic and secular; it popularized itself in the United States so directly with the people that the various State governments, recognizing that the beneficiaries—who at first were of the class that, *un*educated, would have become a charge to the nation—grew self-helpful, were imbued with the desire to extend educational advantages. Under the sway of popular enthusiasm large sums of money were appropriated; schoolhouses were erected at public expense in all large cities, and in almost every village.

The primary thought of the founders of the new schools was lost: this consisted merely of giving a groundwork of education for pupils to build upon. Grammar and normal schools, as well as universities, arose throughout the land. College text-books were multiplied seemingly without end, and from them everything within the ken of human understanding was attempted to be taught. Instead of the original plan of three or four years being the average length of school-life for *non*-professionals, children were entered at five years of age and left as young men and women graduates.

This system of book-cramming, which was not only without science, but was founded upon neither experience nor observation, was followed by the most unsatisfactory results. The exclusively scholastic knowledge which was imparted unfitted the common people for the exigencies of actual working-life. This guidance of theocratic, feudalistic, and merely scholastic teaching did not result in any adequate social, moral, and intellectual improvement. Is it not time, then, that *Science* and *Art* shall assume control of the free schools of America, and convert them into halls of industrial and practical education?

PREHISTORIC RUINS IN SOUTHERN COLORADO.

By HENRY GANNETT.

FROM the southern and western slopes of the San Juan Mountains, in southwestern Colorado, stretches far to the south and west a strange country. It is a country of plateaus and cañons—of plateaus whose surfaces are flat and unbroken for miles on miles; as far as one can see, the country presents a monotonous level, but is cut here and there by deep, almost impassable, cañons. As we recede from the mountains, these plateaus, which are there covered with piñon pine and sage, become more sterile, and finally vegetation ceases, except in isolated spots, and the surface is bare rock or drifting sand—a very Sahara.

The Rio San Juan heads in the southern slopes of the San Juan Mountains, and, flowing at first south, at a distance of about fifty miles turns west and keeps this course generally to its mouth. It flows through the middle of this desert country, fertilizing a narrow belt along its course.

In the region drained by this river there is little water. Of the branches which enter it from the north, there is but one stream west of the La Plata which succeeds in reaching the main river. This is the Rio Mancos. All the others, and they are numerous, start from the mountains as large, clear, beautiful streams. They reach the plateau; the water becomes discolored, alkaline, and in a few miles disappears. The dry atmosphere and the parched earth have absorbed it, and a dry cañon alone remains to mock the thirsty traveler. Reaching the edge of one of these cañons, five hundred or perhaps a thousand feet deep, with precipitous sides, one experiences a feeling akin to superstitious fear when, after descending to the bottom, and fully expecting to hear the rushing of a torrent of crystal water, he finds only a stream-bed of hot, glistening sand. The feeling is the same which one has on seeing any other monstrosity. Why this great cañon carved out of solid rock? Where is the agent which has produced such stupendous effects?

Doubtless in the early spring, when the snows in the high mountains and on their lower slopes yield to the power of the sun, these stream-beds are for a short time—a week or two, perhaps—each filled with a rushing torrent; but, like the people who once dwelt near them, the perennial streams, which in time past cut these gorges, have disappeared. Throughout this vast region, with the exception of the streams mentioned, the only water to be had is in springs and in water-holes, where rain-water, protected from the ardent rays of the sun, remains for a time. The sources of supply are precarious, and, without a knowledge of their location, one might travel for days without finding water.

Scattered over the region are the remains of a long-forgotten people—a people which, judging from the few relics left for our study, possessed a far higher degree of civilization than the wild tribes now roaming the country, higher than the Moquis and Pueblos of the present day, yet resembling them in many respects. We find the remains of their homes, their houses of stone, in various places and of various kinds: some, the homes of a happy, contented people, in full security, leading a pastoral life; others, mere *houses* built for shelter and defense in stormy times, as protection from the invader, for concealment, and for open defense. The general outline of their history is written in characters of stone all over the country.

The northern limit of their settlements seems to have been near north latitude 38°. Farther north than this no evidences of their occupation have been discovered, although exploring parties have examined the country thence to the Grand River. Toward the south and west their dwellings have been found in Utah, throughout Arizona, and in New Mexico as far east as the Rio Grande. But here, on the

Rio San Juan and its tributaries, seems to have been a center of population. In this country, over a large area, the villages are quite near together, showing that it was comparatively densely peopled. Their remains consist of buildings in various stages of decay and dilapidation—cemeteries, pottery, most of it in a fine state of division, arrowheads, a little wicker-work, stone tools of various sorts, partially carbonized grain, corn-cobs, etc., and a few specimens of human remains.

The ruined buildings are, as was stated briefly above, of two general classes, representing two different periods in this ancient history, that of peaceful occupation, and that of invasion by a foreign power and of final expulsion of this people from their homes. All of these structures are of stone, dressed with more or less care, or chosen with reference to size and shape. There is little or no rough rubble-work. In all, the stones are set in adobe mortar, which has great cohesive power, as is shown in several examples.

The first class of structures is found on the fertile bottom-lands, close to water, and they are not arranged with the least regard to defense or security. They were the homes of an agricultural people, and were doubtless surrounded by fields of waving maize and orchards of peach-trees, while herds of goats pastured on the lower slopes of the *mesa*. The men labored in the fields, and took care of the herds ; the women assumed the household duties, wove blankets, and molded pottery. But these happy days came to an end : the invader descended from the north and sought to drive them from their country. Long and deadly was the fray. They were driven from the fertile bottom-lands, and were forced to build houses, like the swallows, in cracks and crannies of the cliffs, wellnigh inaccessible from above or below ; or they built strong fortifications on the mesas. But all was of no avail. One by one their warriors fell ; step by step they were driven southward, until at last, totally discouraged and disheartened, and with ranks terribly thinned, they abandoned the homes of their fathers, and wandered southward, some to build on almost inaccessible heights—the Moquis towns of the present day—some to wander to the site of Zuni, others to the Rio Grande, where their descendants are found to-day : but, as is so often the case with a people forcibly transplanted from their native soil, they have deteriorated from their former state of civilization.

The buildings most frequently met with are rectangular or circular. The commonest form for dwelling-houses is the rectangle. In all cases where possible the dwellings are semi-communistic—that is, each of the houses is very large, intended to contain a number of families, but is divided into many rooms. In some cases, these dwellings, especially in agricultural towns, are from one to two hundred feet in length. At Aztec Spring, a few miles north of the San Juan, is a very large town, built in one mass, and covering 480,000 square feet. In the midst of this, one building, standing by itself, seems to be the principal house of the town, judging by its dimensions, thickness of its walls, and the care displayed in dressing and laying the stone; also by the presence of a circular room, which, as will be seen hereafter, is their temple and council-house. On the La Plata there is a large agricultural settlement, very much dilapidated, which consists mainly of houses of this kind. The largest of these is one hundred by one hundred and fifty feet. These dwelling-houses seem to have been very similar to those in the *pueblos* of the present day. A high wall was built, inclosing a rectangular space. The house was built all around the interior of this wall, which thus became the back wall of the house. In the interior was a rectangular court, on which the house opened. There were no openings for egress or ingress through the wall; the only way to obtain admission being to climb over the wall, by a ladder, and descend in the same manner to the court. The house was divided into many rooms, and, except in a few cases, they did not connect with one another directly.

None of the ruins of these houses thus far examined are in such a condition as to enable one to determine whether they had more than one story. In the pueblos of the present day they are found of three and even four stories in height.

In the towns built in time of war, for defensive purposes, these dwellings are usually much smaller than in the former case, and could have accommodated comparatively few persons: but this is due to the circumstances of building-site solely; for everything in their history shows them to have been a gregarious people. These towns were evidently built later, and in many cases are so situated as to be much better sheltered from the elements, and naturally are found in a much better state of preservation than the former.

In every village, whose site would admit of it, these people have built one or more cylindrical towers, which seem to have been used as council-houses or temples, or both. The walls are generally double, a tower within a tower, and, in one or two cases observed, there is a third tower. The space between them, several feet in width, is divided by radial partitions into rooms. Within the inner tower, the ground is excavated, forming an hemispherical depression. Here it has been supposed that the eternal fire was kept; and it has been suggested that the circular section of the building was intended to symbolize the sun, the object of their worship. These buildings are, in all cases, the most thoroughly constructed; their walls are thicker and of larger and better-dressed stones than in any other buildings. Structures quite similar to these are found in the pueblos of the present day, and are used for the purposes above mentioned. They are always found in agricultural towns, and in fortified towns on the summits of mesas, but in most collections of the cliff-houses and in the cave-dwellings they are of necessity absent.

Well-preserved specimens of these structures have been found on the edge of the mesa above the San Juan, a few miles from the mouth of the Mancos. Here there are two towers on the very edge of the mesa, so close that the outer walls are not complete, but are open toward the cliff. In the smaller of these towers, the outer wall is twenty-two feet in diameter, the inner twelve feet. In the larger tower, the diameters of the walls are respectively one hundred and forty and one hundred and twenty-three feet. Both are much broken down, so that the original height can not be estimated. In the face of the cliff, directly beneath these towers, are several cave-dwellings connected with the top of the cliff by steps cut in its face.

In the cañon of the Mancos, on the river-bottom, are the ruins of a large tower, the diameters of whose walls are respectively forty-three and twenty-five feet.

On a low bench near the McElms, a dry cañon which heads in the plateau, and enters the San Juan below the mouth of the Mancos, is a large settlement. On one side of the town is a large tower, remarkable as having *triple* walls, whose diameters are respectively forty-five, thirty-five, and fifteen feet. The space between the outer and middle walls is divided by partition-walls, while that between the middle and inner walls is not. In this and all other such structures there are no openings through the walls into the interior apartment. Access to it was had probably through a subterranean passage, as has been observed in at least one case.

Connected with the agricultural and mesa towns are, in many cases, watch-towers usually of circular form, perched on fragments of rocks in commanding positions, whence the approach of enemies can be detected. These are small and with single walls. In the neighborhood of some agricultural settlements are holes dug in the earth, and the earth thrown up in heaps in front, as in rifle-pits. They probably were made for a similar use.

The rocks of which the cañon cliffs are composed are of sandstone and shale. The former is hard and is acted on by the elements slowly, while the latter is easily disintegrated. Hence it is common to find that strata pathways up the cliff have disintegrated faster than those above and below, leaving horizontal crevices of greater or less height and depth. These crevices have been utilized by these people, when hard pressed by their enemies, as strongholds. They built walls across the whole fronts, leaving only little holes for egress and ingress, light and air. Thus walled in, their position was absolutely impregnable from above or below. It is astonishing in what a limited space these beings contrived to exist; some of these cave-dwellings are scarcely large enough for a man to crawl into.

More pretentious than these are the cliff-houses, which are built in similar situations, differing only in the height of the crevices. Many excellent examples of these have been found. They are generally well preserved, as their situations protect them in great measure from the elements. There are several in the cañon of the Rio Mancos. In one place there is quite a large village, consisting of a series of rooms opening toward the back of the crevice, and with a smooth wall in front, broken only by a few small openings for air and light. Near the middle is the council-chamber, a circular room, as elsewhere, entered only by a very long, low, covered way, or tunnel, built of masonry. This is one of the very few cases where, in similar locations, there was more space than was absolutely essential for mere existence, and the extra space was forthwith devoted to this building, which shows that to it they attached great importance.

Above this village is a crevice similar to the one in which it is built, and this has been utilized as kitchen and storehouse, as is shown by beans and corn which have been found there in a good state of preservation. In the main village whole earthen pots have been found. It is a rare occurrence to find whole vessels, though fragments of them are as plentiful on the mesa as leaves in Vallambrosa's shades.

In another place in this cañon there is a single house high up on the cliffs, which rise still higher above it. It is of two stories. The remarkable feature about it is that the outside is covered with plaster, and painted to resemble the adjacent rock, in red and yellow grays, in the hope of avoiding detection. The insides of the front rooms in each story also are plastered and colored a deep maroon red, with a dingy-white band. Adjacent to it is a cistern to catch and hold the water which trickles down the rocks.

The Casa del Eco is one of the largest of these cliff villages. It is in the cañon of the San Juan, about twelve miles below the mouth of the Montezuma, a dry cañon which heads in the Sierra Abajo. The cañon-cliffs at this place are about two hundred feet high. A vertical and horizontal section of the cliff both present the form of a semicircle ; in other words, there is here a cave, in the form of a hemisphere. Along an horizontal curve which passes through its deepest part is a stratum of harder rock, ten feet wide at its widest part, making a projecting shelf, on which is perched the single row of houses of which the town consists. Here the people were entirely protected from attack from above, as the overhanging wall of the cliff projects at least one hundred feet. Below, the slope is extremely steep, making approach in that direction slow and tedious ; and, finally, the shelf on which the town stands projects so far that it is wellnigh impossible to get on it without outside aid. The main building of the town, the council-house, is, in this case, rectangular, forty feet by ten, and twelve feet high. It is built in two stories, and each is divided into three rooms. The floor-beams of the second story are of the cedar so common in the country at present, prepared merely by stripping off the bark. Whether these houses had roofs, it is impossible to say. In so protected a situation as this they would be of little use.

In the mortar of these houses there has been detected the imprint of the fingers of the builders, showing even the fine lines of the texture of the skin, and in one or more places the impress of a complete hand. Their hands appear to have been smaller than the average. Indeed, everything tends to show that this was a race of small stature.

To gain access to these elevated abodes, the people made use of ladders, and of niches which they cut in the rocks.

The amount of labor involved in the construction of these towns was, for a people so absolutely dependent on their own unaided labor, enormous. In some of the cliff-houses, the stones had to be carried for hundreds of feet, up precipitous walls, where the only footing was by holes which they had cut in the rock. All the stone used in the enormous buildings at Aztec Spring was brought from the foot of a cliff fully a mile away, and this without the aid of beasts of burden.

Fragments of pottery are found everywhere. Indeed, it is slight exaggeration to say that the plateaus are paved with them. One may ride for miles with the constant accompaniment of the ring of the horse's hoof against the relics of the ancients. The amount of pottery which this people used was enormous. It would seem that careless servants are not among the innovations of the nineteenth century. Few whole vessels have been found; few, even, of large fragments. These vessels are variously ornamented. The surfaces of some are corrugated, apparently with the thumb-nail; on some, raised figures are seen; others, and these are by far the most abundant, are glazed, and covered with all conceivable figures, rudely painted.

The pottery resembles very much that made by the Moquis and other similar people to-day, but is in many respects superior to it. Arrow-heads seem to have been another staple article of manufacture, judging from the abundance of the specimens. They are made of varieties of quartz; and beautiful specimens, made of smoky quartz, chalcedony, moss agate, and opal, have been found.

The cemeteries which have been examined present a family resemblance. The graves, or family lots they may be, are surrounded by flat stones, set on edge in the earth. The little lots thus marked out are rectangular in shape, with sides six to ten feet in length. Several of these were opened, but nothing was found except a little charcoal.

With regard to the age of these ruins, and the date of the occupation of this country by these people, little has yet been learned. The erosion of cliffs in the neighborhood of the cliff-houses gives no satisfactory data on which to found an estimate. The cemeteries and some of the ruins are overgrown by large pines and cedars, some of them a foot or more in diameter. The Moquis and Pueblos have no traditions concerning these people, who were undoubtedly their ancestors. But neither of these facts gives more than the very general idea that the date of their occupation of the country was several centuries ago.

The ruins are, in many cases, found several miles from the nearest water—a fact which shows conclusively that at the time when these dwellings were inhabited the country was better watered than now. It has been suggested that these houses were inhabited only for a part of the year, when the streams were high from the spring freshets; but, as the structures are of stone, built with great labor, and in a permanent manner, and as the season when there is water in the streams is at most of but a few weeks' duration, the theory seems scarcely tenable. Moreover, within the observation of white men, the amount of water has decreased. Springs, which a very few years ago were important watering-places for travelers, have decreased in size, and in a few cases have dried up. Still, at that time the climate, though less arid, was in a measure such as it is now, since we find the timber used for beams, etc., in the houses, is the same species of cedar now so abundant on the plateaus—a species peculiar to a dry climate.

The study of the ancient inhabitants of America is one of surpassing interest, and the deep mystery in which the past is wrapped only adds to the zest with which we strive to draw the veil away. But thus far little has been discovered. We know that at some time, far back in the dim past, a great people lived in the Mississippi Valley; that they built there enormous structures, mere traces of which remain, scarcely enough to mock at the seeker after their history. Whence they came, and whither they went, we know not. In the Southwestern Territories we find these structures of a semi-civilized people—whether the same as the mound-builders, no one can tell. No one knows their earlier history; their later history has been sketched in its general features.

THE CONVENT OF THE CAPUCHINS.

By ARTHUR SEARLE.

TRAVELERS to Rome, endowed with a reasonable measure of that taste for the repulsive which is natural to our paradoxical race, have long been accustomed to include in their round of sights a Capuchin convent, noted only for the singular manner in which the bones of its deceased inmates have been made to serve as emblems of mortality to the devout. The published accounts of the spectacle here presented are too generally familiar for quotation. A letter before me, dated in November, 1821, will furnish a description which will at least have the merit of not having already appeared in print.

"I went to the cemetery of the Capucins" (the writer adopts the French spelling of the name), "where we found, in the cellar of the convent, forty graves in the loose earth, always occupied by Capucins in their usual dress, without coffins. When a new man dies, they take up him who has been longest in the earth, coat and all, and place him on his feet in a niche left in the walls of bones, several feet thick, which ornament the rooms. The niches being also always full, they are obliged to make room here, too, for the new-comer by breaking up and scraping the skeleton which has stood there longest, and adding his bones to the different arches and festoons which are gracefully distributed on all sides. The convent is not very full just now, so that the poor fellows rest on the average seven or eight years in their graves; formerly they were often dug up in two or three."

The earth affording this limited privilege is said to have been originally brought from Jerusalem, so that quarters in it were regarded as peculiarly desirable by the originators of the custom just described; but no doubt an equally important reason for establishing the practice was the desire to edify the living monks by the exhibition of the remains of their predecessors. Heretic sight-seers had not then begun to invade the city. If, however, the possibility of their visits had been foreseen, it might well have been supposed that the silent warnings of the dead might be more effective in their conversion than the arguments of living preachers.

It will hardly be thought that any mere secular sermon may also be preached upon the text furnished by this assemblage of bones. But we have here one solution of the problem, so much discussed in our times, of discovering the proper method for the disposal of dead bodies. We need not allow the various offensive circumstances connected with these Capuchin interments to conceal the main principle upon which they are conducted. The corpses are left to rest some years, without coffins, in dry, sheltered earth, before any step is taken toward their final disposition. If we consider these facts alone, we shall have no difficulty in perceiving that the chief objections to our common funeral usages, and to those substitutes for them which are most frequently suggested, have been met in advance by the Capuchins. The cellar, the standing skeletons, and the festoons of bones are not essential features of the method of interment which they have adopted.

What, in fact, are the causes which have brought coffins for the dead, with all their disagreeable and dangerous consequences, into such general use? Undoubtedly, our natural wishes that the bodies of our friends should be protected, and not left exposed to accident or violence of any kind. Interments without coffins in open cemeteries will hardly be acceptable to civilized people, however much from a sanitary point of view they may be preferable to the customary method. It is needless to engage in a discussion of the repulsive incidents which must or may attend either the use or the abandonment of coffins. We have had them unpleasantly set forth time and again, and may assume at once that all of them are, if possible, to be avoided. The ground ought not to be poisoned either more or less; and we have not room for so wide a separation of one corpse from another as to make our interments quite harmless.

It may here, of course, be objected that the earth is really spacious enough for all our wants, and that crowded cemeteries are the result of heedlessness, not of necessity. But in this remark there is no more truth than in the commonplace answer to Malthusian arguments, that there are plenty of thinly settled districts still to be occupied. Space there is, no doubt, both for the living and for the dead, if they could be conveniently carried to it ; but there is often too little space where people find themselves obliged to live and die. Crowds are a necessity of progress, it seems ; at all events, the art of getting on well in solitude has not yet been discovered, and we are required by nature to find ways of helping our neighbors where they are, rather than of sending them away. At least, let us find ways to avoid injuring them.

Provision must be made in the neighborhood of large towns for numerous interments. The land available for the purpose is limited by the wants of the living, who can not afford to leave large tracts unoccupied. To make cemeteries serve the purpose of parks and pleasure-grounds would be certainly indecorous and probably unwholesome. On the whole, it is scarcely possible that, under existing circumstances, our burying-grounds should not be overcrowded.

For the inhabitants of maritime districts it has been suggested that the sea, at a sufficient distance from shore, might serve a good purpose as a cemetery. But the practical objections to this plan, resulting from occasional periods of stormy weather, and from the impossibility of recovering corpses wanted for identification or for medical examination, are sufficient to condemn it. It would, moreover, be disagreeable in most cases to the feelings of surviving relatives and friends, and acceptable only when, as at present in many cases of death at sea, it is the only practicable method.

Most of the objections just enumerated apply with equal or still greater force to the more frequently discussed method of cremation. It is not desirable, either from a legal and medical or from a sentimental point of view, that a body should be destroyed soon after it has ceased to live. To effect this destruction in a thorough and decorous manner by burning is expensive, if attempted without complicated apparatus, the original cost of which must, in any case, be considerable. We may neglect more remote and perhaps fanciful objections, such as, for example, that the world's natural stock of ammonia might be seriously reduced in the course of centuries, if the process of decay were extensively replaced by that of complete combustion.

After reviewing the various substitutes for burial which have been tried or suggested, it happens with most minds that none of them seem on the whole to be improvements. It remains, then, to find a form of burial which will accomplish its purpose effectively and without offense or danger to the living. This form must, accordingly, be such that the earth employed for the purpose of burial shall be free from moisture or any other hindrance to rapid and inoffensive decomposition, and entirely separated from the ground through which the rainfall which feeds our springs and lakes is to pass. The corpses must be buried without coffins, and still be protected from disturbance or defacement by animals of any kind. The only means of securing these ends is apparently to have all interments made in dry earth contained in secure and properly ventilated buildings.

It is, of course, impossible that under such a system the same place should not, as a general rule, be used repeatedly for successive interments. This is mainly a question of expense. In most cases, after the course of nature had thoroughly removed all that could decay, there could be no objection to the disinterment of the skeleton. Cremation would now be a comparatively cheap method of preserving the remains from any treatment which might be held to be indecorous, and the passage of time would ordinarily have removed all occasion for the natural feeling which makes us shrink from doing any violence to a recent corpse. The earth used for the interments might, of course, be thoroughly heated at long intervals, to destroy any accumulation in it of organic products ; or, indeed, unless the expense were considered a foolish one, charcoal might take the place of earth, and be ultimately burned with the bones contained in it.

A principal advantage of this method of interment is that it may be employed at any time by individuals without waiting for general adoption. A water-tight tomb may be constructed without very great expense in any ordinary cemetery, and, if the ground around it is suitably drained, may be used for a long while without fear that it is a menace to the health of the community, as all ordinary graves and tombs undoubtedly are. The most economical way of providing sheltered graves, however, would probably be to erect for the purpose buildings of considerable size, within which space might be hired in perpetuity or for limited terms of years. It is possible that such buildings might stand at no great distance from others without harm, under suitable regulations for the interments to be made in them. If constant attendance were provided for, the fear of premature interment which distresses some people might be to a great extent removed ; and in any case the protection of the corpses might thus be efficiently secured. Memorial tablets, which might finally be removed to any place selected for the reception of the harmless ashes, would be a welcome substitute for the clumsy monuments which disfigure our present cemeteries ; and, without any of the offensive circumstances attending the interments of the Capuchin convent which have served for the text of this article, we might apparently secure their substantial advantages of economy of space and moderate rapidity in effecting the true purposes of burial.

ATHLETICS IN SCHOOLS.

THE Honorable Edward Littleton, an authority in English higher education, has written a notable article in the "Nineteenth Century" on "Athletics in Public Schools." He canvasses the system with some thoroughness, and arrives at independent conclusions regarding it, which will be of special interest on this side of the Atlantic, now that such vigorous efforts are making to adopt the same policy in our higher schools. We accordingly give a summary of the chief points of his essay.

He begins by remarking that intelligent Frenchmen are in the habit of highly commending the English public schools. But, when asked the reason, they always refer to the admirable "*culte* of athletics" which English students enjoy. This surprises the Englishmen—first, because the French have no such thing in their schools, and the Frenchman is therefore speaking about that of which he knows nothing; and, second, because the English themselves are beginning to have profound misgivings in regard to the influence of this marked feature of their educational system.

Mr. Littleton first states the undoubted advantages to be derived from athletics. They are to be encouraged on the grounds of health, as there is unquestionably an hygienic value in games for boys. Again, pastimes afford a relief from the repulsive restraints and monotonous labors of the schoolroom, and are thus promotive of enjoyment. There is, moreover, a benefit in the discipline they afford. The boy who is a member of an athletic club or combination is "forced to put the welfare of the common cause before selfish interests, to obey implicitly the word of command, and act in concert with the heterogeneous elements of the company he belongs to." Those, besides, who secure the posts of command, "feel the gravity of responsible office, and the difficulty of making prompt decisions and securing a willing obedience."

But the difficulty at once arises how to restrain athletics, so as to get only their undoubted advantages. They have a tendency to excess which becomes subversive of the fundamental objects of the school; and for this excess Mr. Littleton shows that the outside public is very largely responsible. How rapidly this influence has been developed and brought to bear upon the schools during the present generation is well illustrated by the following passage: "Any one who played in the Oxford and Cambridge or Eton and Harrow cricket-matches thirty years ago can testify that there were scarcely enough spectators to form a continuous line round Lord's cricket-ground. In the latter match it was not found necessary to use ropes till 1864, while now, such is the importance of the annual pageant, that it affects the duration of the London season. At about the same date a few keen partisans gathered together to see the universities contend in rowing. Little was said about it, scarcely anything written. Nowadays the crowd assembled to see the practice of the crews equals the number of those who used to watch the actual race; moreover, the minutest facts connected with the play of each oarsman's muscles are anxiously picked up on the spot, form a paragraph in the daily papers, and are telegraphed to the antipodes. Deducting from all this the influence of fashion and the mere gregarious tendencies of society, it is quite clear that there has been a dead set of public feeling toward increasing the importance of all athletics. In short, the tide has borne all before it, and scarcely a warning voice has been heard hinting at the possibility of going too far; and, consequently, very many boys soon after they enter the schools (some of them before) are impressed with the notion that athletics are to be pursued as the one important thing—in conjunction with reading, perhaps, *si non, quocunque modo*—but pursued with every nerve they must be."

Of the elements of danger developed in the system under this powerful pressure, the writer remarks: "At first sight, any one would say that its chief danger in the present day lies in the superfluity of time devoted to various out-door pursuits at school. This is wrong. I do not deny, of course, that too much time may be, and not unfrequently is, absorbed daily by games; but that is not the chief danger: authorities could easily suppress an extra hour or two if they saw fit. But it is not generally realized that the effects of games last far beyond the close of play-hours. Leaving out of sight all physical considerations, over-fatigue, etc., which are nevertheless very important, let us look merely at the effects on the mind. Suppose the case of a lad in a school where athletics are much thought of, who is perhaps just emerging from obscurity because it is found that he can row or bowl well. He finds himself with an unlimited prospect of fame before him; if he makes a great struggle, some important step in his 'young ambition's ladder' will be reached; he will be elevated into a social atmosphere now tenanted by the high ones of the earth, who look down on him scornfully, but, in the event of his success, would soon be walking arm in arm with him. A fascination, unimaginable by the outside world, urges him onward, and, with a sense of his increasing importance, comes an increasing appreciation of the method by which he has risen; so that, even with his books before him, his mind is wandering among the scenes of his ephemeral triumphs and reverses while he ruminates on his last big innings or the prospects of distinction in a coming foot-ball match. Prizes, places in the school, are but little things, and are treated as of little worth. This statement of the case is not a whit exaggerated as far as the majority of athletes are concerned. It needs a very exceptional boy indeed, after having been engaged in an absorbing pursuit, to unshackle straightway his energies and thoughts simply at the call of duty, probably uninviting, irksome duty. But the athletes are not the only ones affected. Wherever athletics are very popular, around the coterie of successful gamesters is formed a large hoard of hangers-on, boys who admire muscle without possessing it, and who, formed by nature for a very different line, adopt the habits and opinions of the superior class, till, perhaps without participating, their interest, too, is absorbed by the prevailing rage, and the tone of the whole community is affected. Under these conditions, work, honest, spontaneous effort in other lines but amusement, is impossible."

The potent fascination of athletic games for boys is undeniable, and that they must greatly interfere with legitimate school-work it would be also folly to question. But, admitting that they hinder intellectual progress, it is common to affirm that there is a great compensation for this loss in the moral benefits of athletic training. It is said that there is a much more important thing in schools than book-learning, and that is to improve the moral tone of students. But Mr. Littleton insists that it is far from being established that athletic games intensely pursued are any check upon vicious tendencies. He maintains that, where athleticism is so engrossing as to stunt the higher life of a school, it is not promotive of virtue, and that, "among schoolboys, the mere students are as a body more virtuous than the mere athletes." He does not affirm that among university students the athletes are more immoral than those who neglect physical recreations. The main question, however, here, is one of mental indolence and vacancy, and Mr. Littleton says: "An energetic athlete, without an idea of any other pursuit whatever, is better off and less likely to turn out vicious than a wholly idle university man or schoolboy; and the appreciation of this fact seems to have led people into investing athletics with a power of stemming vice; the truth being that they are in a limited degree obstructive of it—but only in a limited degree; and it is quite erroneous to suppose that in any educational institution a predominance of athleticism necessarily brings with it a high standard of morals." It is the absolute supremacy of recreation over study and the resulting lack of steady and wholesome mental occupation that lead to immoral consequences. A positive and serious evil of athleticism is, that it tends to become a power in the schools, rivaling the constituted authorities, and that is capable of becoming an enemy to discipline. The spirit of athleticism becomes organized, and the class devoted to it, representing the most powerful feeling in the institution, grows formidable, so that the teachers must ally themselves with it, or lose their control over the pupils. "As is sometimes remarked, no public functionary, no clergyman, no military commander, certainly no prime minister, assumes his powers intrusted with such absolute and unquestioning confidence as does a prominent public schoolboy. His opinions are not disputed, no opposition benches are ranged against him; but his lightest utterance carries law with it, and in questions of right and wrong his behavior goes far to shape the yet pliant dispositions of those around him. . . . These, then, are the dangerous aspects of athleticism. It is liable, if allowed full play, to damage seriously the intellectual interests of a school, without raising appreciably the moral tone, and also to become a hindrance to school government. It is quite obvious, then, that great care should be taken to control this development of school-life. It should be looked upon as ever tending to form an excrescence."

Mr. Littleton next proceeds to inquire how the evils of excessive athleticism may be diminished. A boy places but little reliance upon any representation of the teachers as to the unworthiness or secondary claims of athletics in comparison with proper educational objects. "He looks upon them as a class bound to preach such doctrines in the position they hold, and that it is only to be expected they should do so; but as for really thinking that they are right, when as it appears to him the whole of England is the other way, that he can not bring himself to do." Here is the difficulty; the motive power is the public interest. "That motive power is the consensus of fashionable opinion which acts externally on the feelings of the school and produces such results." But, as it is futile to try to correct public opinion, the only way is to prevent its taking effect by withdrawing the boys from its influence. It is in the power of the authorities to prevent those public contests which kindle such widespread public enthusiasm, when the interest and applause of multitudes are presented to the boys in their most imposing and dazzling form. That is, intercollegiate regattas and athletic contests of all sorts, which draw out great masses of excited people, had better be avoided in the interest of sound education.

But, while the prestige of athleticism might be diminished by guarding in this way against external influences, Mr. Littleton recognizes that the plan would have to be supplemented by agencies of a very different character. The school-work itself must be made more attractive. He sees that there is a very important change in the higher education of late years, which is not without promise of counteraction to the excessive devotion to sport. This change in the objects and methods of the school is thus described: "Certain conditions have given birth to a now widely-accepted theory of education, which in all probability will effect still more marked alterations than it has hitherto. The conditions are these: Owing to the increase of population on the one hand, and the advance of learning on the other, we are brought face to face, not only with an increasing number of subjects to be learned, but also with an increasing necessity of learning them. Many members of the class from which, thirty years ago, the ornamental men of leisure were recruited, now find that existence has assumed to them a more somber hue; paths formerly open to them are open no longer, and through knowledge alone an access to ease and affluence is to be obtained. Accordingly, the avenues to knowledge have been made smooth, and everything invites the unwilling to learn. The results of many years' unintermittent labor are presented in a compressed form in every description of hand-book and pocket-primer, for it is only permitted to a comparatively few to remain ignorant and be content therewith. The field of knowledge has thus been greatly extended and opened out, and a great diversity of subjects have been grappled with, in one way or another; and, in spite of the fact that much of this great movement produces a paltry caricature of learning, new interests have been excited and minds stimulated which would have lain stagnant before. The managers of the various seats of education have roused themselves to supply the needs of the time and extend their resources; and they now present to the public a programme far broader and more inviting than that of a quarter of a century ago. In this way various special lines of education have been more widely adopted, and their adoption has influenced the purely general education, with this result: Men now perceive that boys' minds are almost infinitely various, and that knowledge of various sorts must be presented to them in various ways—anything to awaken interest and encourage *voluntary* intellectual effort. Now, it is from the development of this theory that I think we may expect results having an important bearing on the matter in hand. The introduction of subjects likely to attract boys' interest and the general idea of teaching them by exciting that interest tend to upset the notion that work is valuable *per se* quite independently of the subjects worked at. It must be admitted that this notion has been allowed every chance. Men have aimed at educing solid effort by a curriculum of study which could only be attractive to a select few. Let us hope that the idea has really had its day, for, besides being, as many now think, comparatively useless in itself, its effect on an overgrown athleticism is positively pernicious. So long as the graver occupations of a boy's life are slavish and detested, he will throw himself heart and soul into any kind of amusement, and set himself to find his only happiness therein, while all knowledge, all that is either useful for practical life, or merely refining in itself, he will vaguely think must be in a way dismal; his view of it will be colored by the memory of the toilsome and sterile hours he has spent with his books. And, even if he is forced to learn something, such knowledge as he gains will be unproductive; he has no affection for it, and does not care to impart it. It is remarkable how many men seem half ashamed even of such useful knowledge as they do possess. If boys' minds are to be elevated from athletics to anything higher, it will not be by such methods as these."

The change of method which Mr. Littleton regards as hopeful consists, first, in modernizing the curriculum of studies, and introducing into it subjects less repulsive than those now in vogue, and which are capable of exciting a readier and stronger intellectual interest. He would strengthen what is technically called the "modern sides," by incorporating various sciences and the living languages into the schemes of study. Subsidiary to this fundamental improvement several other resources are thus referred to: "But the movement has not stopped here. A further and most satisfactory result is noticeable in the recent establishment of workshops under proper control, where boys can gain some idea of the value of manual labor, and the respect due to careful handicraft. Museums too are encouraged, since they help in extending the front, so to speak, of the intellectual interest presented to the boys, and so increase the chance of alluring a greater number to pursue knowledge for its own sake. For those who know the natures of average boys know that the process of leading them to learn is in reality a process of allurement. Thousands of boys have a strong instinctive antipathy to intellectual effort; their point of view with regard to it has been modified; and if the attempt is made abruptly it will be ineffective; they suspect some sinister design, not knowing yet that what they are being led to is beautiful for its own sake, and capable of making them useful members of society. And, to further this innocent deception, such things as debating societies are valuable. They may induce an intellectual activity in quarters where there is often a marked tendency to stagnation, and stimulus may be given to thought, arrangement of ideas, and the hearing and imparting of facts, without aid of lexicons or fear of the ferule. But they are not often made to serve this purpose without considerable efforts being made toward sustaining them after they have once started. Transitory conditions may start them, and then generally a crisis supervenes demanding great care. Supposing, however, that this has been survived in safety, the society is liable to change its character. The debating element in its constitution is seen to lose prominence, and a club is formed of boys elected for their popularity, an aggregation of the influence of the school. There is of course a natural tendency to this, and the result is not unsatisfactory. Such a club embraces a class of boys whom a purely literary or debating society would probably exclude. They join it without the least intention of learning anything; but its usages should compel them, by means of debates, to take a livelier interest in rational subjects and enlarge their mental horizon. But there will very likely be room then for a purely literary society of a less compound nature, to coexist side by side with this club, and provide solely for the more studious portion of the community. For it can hardly be expected in any school that a club, with members elected for popularity, should coincide with another consisting of the scholars and the foremost devotees of learning.

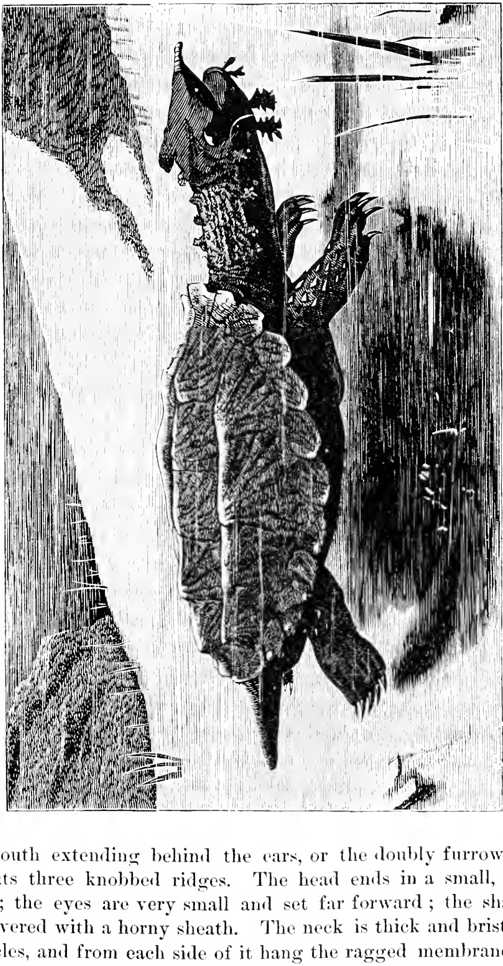
"Many schools also publish periodicals, written and supported by the boys themselves, and these periodicals are of two characters: those devoted wholly to the record of athletics; and those which, besides being athletic journals, contain original compositions, both poetry and prose. They serve a useful purpose, as well as the societies, by fostering a mental activity among the class hardest to reach. Many a young athlete must have first been induced to exert his immature powers by writing (say) some reflections on certain aspects of football. The theme, doubtless, is somewhat humble, but he has to do his best, as his readers know the details of the question thoroughly, and will express their opinion as plainly as any weekly review. Perhaps he learns for the first time that having ideas is not the same thing as expressing them. But to promote the existence of journals which deal entirely with the school-games is dangerous. A very definite impression is made on the younger boys, if they are led to think there is only one subject on which their superiors think it worth while to express their ideas. An indefinite prestige is added to any subject, and still more to any name, by being immortalized in a few lines of letter-press, and it seems advisable that this glamour should not be thrown around one set of interests solely. The periodical should have a double character, and ought to act in the same way as the two kinds of debating society existing together ; the serious portion of the journal would be the field for the literary effort of the studious and the scholar-like, as the literary society would be for their speeches ; while the athletic records can teach athletes to write, just as the debates of the fashionable club would help them to speak."

But again, and in another aspect, Mr. Littleton sees that the question is complicated with outside influences. If public opinion strengthens excessive athleticism on a grand scale, by making it a popular show, the feeling for it is also fostered in the family, so that boys' heads are filled with it before they enter school. Here, also, as in many other matters, the weakness and folly of parents have a baneful efficacy in hindering educational improvement and school reforms. On this point it is remarked : " But what is to be said about the life at home? It is a farce to talk of debating societies and the like being available to combat this or, indeed, any other difficulty, so long as boys are sent to school primed, since the nursery, with the one idea that amusement is to be sought at school, and that a boy, if he is worth anything, will find it and make the most of it. The efforts of the professional teachers depend, to a great and generally unappreciated extent, on the cooperation of the parents. Meantime, the mischief is frequently done before the school-training begins. It is not very uncommon to find parents who have sent their son to a fashionable school, previously urging him to keep out of debt and make suitable acquaintances, but at the same time warning the poor child against getting too fond of books. Others, no doubt, are more cautious ; but the traces of a genuine stimulus hence toward useful work are lamentably rare, and more rarely still are habits of reading encouraged away from school. Not, however, that we need always postulate reading ; we may, perhaps, confess to a strong bias in its favor; we may recollect that discerning men, when the great literary preëminence of Germany is talked of in their presence, have been wont to point with pride to the broad diffusion of pure literary interest through the upper strata of our society, quite independent of any profession or hope of emolument, and challenge one to find the like in foreign lands; and we may judge from such indications as I have spoken of, and doubt if this superiority is as noticeable as ever. Again, we may feel, besides this, that to bring up a boy in ignorance or contempt of reading is, from many points of view, a deplorable error. Non-reading parents, we may think, do not know what it is they are keeping from their son; how they are depriving him of a great safeguard against temptation in his youth, and a lasting resource against weariness in his maturer age. They can not know what it is for harassed minds to be able to turn to literature and find there a refreshment that never fails in the midst of petty worries or heavy affliction, and, not knowing this, they tell him that he can do without reading, as if it were a thing of little worth. All this we may feel, but it is only a matter of opinion; our point of view just now may be thought peculiar; anyhow, we readily admit numberless other methods of awakening in a boy a genuine interest in one, at least, of the multitudinous forms of intellectual life which expand daily around him. There is no excuse for sending a boy to school with a disposition framed for frivolity, with idle instincts to be freshly infused by every holiday-time; whenever it so happens, something has gone wrong which need not have done so, and yet so it happens in thousands of cases every year. Parents do not do this designedly. It is not easy to realize at once that a boy requires incessant support if he is to overcome his natural antipathy to learning anything, and certainly they have very little idea what are the dangers attendant on an idle school career. Anyhow, the result is an influx into so many schools of boys bred up to a spirit of inertia, and encouraged hence to nourish it. From this unwise preparatory training the unruly growth of athleticism has sprung."

THE MATAMATA.

By E. SAUVAGE.

PIERRE BARRÈRE, in an essay on the natural history of the equatorial possessions of France, written in 1741, described a tortoise of a singular form which the Indians of Guiana called the *raparara*. It had, he said, a long, wrinkled neck, from which hung small membranes, ragged or slashed like a fringe; its head was flattened and triangular, and ended in a kind of trunk shaped like a quill-pen ; and the upper part of the shell was furrowed and marked with large knobs. This concise description gives a fair idea of the principal features of the tortoise which is illustrated in the cut. It is hard to tell which most attracts attention, the large, triangular, depressed head,



THE MATAMATA (*Chelys matamata*).

the mouth extending behind the ears, or the doubly furrowed back with its three knobbed ridges. The head ends in a small, movable snout ; the eyes are very small and set far forward ; the sharp jaws are covered with a horny sheath. The neck is thick and bristles with tubercles, and from each side of it hang the ragged membranes which float in the water. The scales of the carapace are raised into prominent knobs, and from the tip of each knob furrows radiate in every direction. The tail is short and obtuse. The long and hooked claws are attached to paws which are somewhat palmated and of moderate length. The carapace is beveled to give play to the hinder limbs, and the cuirass is narrow and hollowed by a deep furrow in its after part. The upper part of the body is for the most part of a brick-red; the cuirass, not so deeply colored, is marked by blackish marblings. According to M. Spix, who has observed the living animal, the scales of the carapace are of a maroon brown, with radiating streaks, and the lower part of the head and the most of the members are of a greenish yellow pricked with brown. This tortoise is a native of the Guianas, and lives in stagnant waters and half-dried marshes. Except at the time of laying its eggs, it hardly ever goes to the land. Immersed in the mud, which it is not unlike in color, it lies in wait for the creatures which are imprudent enough to swim near it. The ragged membranes, floating in the water like worms, attract fish seeking for food. When a suitable prey passes within reach, the head which has been bent to one side instantly darts out as if it were hurled by a spring, and the victim is quickly buried in the huge throat of the reptile.

This tortoise, described by Barrère as the raparara, has been called by Schneider the Sinibrian tortoise. Bruguibre, in his "Journal d'Histoire Naturel de Paris," has given it the name of *matamata*, which is generally accepted by modern zoölogists. The only species from which the genus *Chelys* has been formed lives in the Guianas; and the individual, which is now to be seen in a living state in the museum at Paris, was captured there by the French explorer, M. J. Crevaux.

FROST-PHENOMENA IN SOUTHERN RUSSIA.

SOME few people may perhaps have remarked and remembered an unusual meteorological phenomenon which occurred in London last Christmas night. We had had several weeks of hard frost, and the cold on Christmas morning was rendered more piercing than ever by a bitter east wind, though indications of an approaching thaw were not wanting. About the middle of the day, snow began to fall; but in the evening this changed to rain, which froze as it came down; and by ten o'clock not only were the pavements covered with a sheet of slippery ice, but walls, lamp-posts, railings, etc., were all glazed in like manner. Every object upon which the eye rested glittered and sparkled, looking as if it had received a sudden coating of glass; while from every roof and ledge hung a fringe of icicles, some of them as much as a foot in length. In the morning, the whole fairy-like appearance had vanished.

This sort of thing does not often occur in England, and, when it does, it lasts but a few hours at the outside; but, in certain latitudes, the requisite meteorological conditions sometimes continue for days and even weeks together, and then the results are most disastrous. The rain continues to fall, and to freeze as it falls; and the crust of ice grows thicker and thicker, until tall trees and miles of telegraph wire are broken down by the enormous weight. Fortunately, the phenomenon is generally arrested before it attains this extreme degree of development, and, when it does occur, seems to be almost entirely confined to the steppes of Southern Russia.

It may be remembered that, during the winter of 1876–'77, frequent references were made in the newspapers to the state of the South Russian telegraph lines, many of which, especially those in the governments of Kherson and Taurida, were rendered perfectly useless for weeks by just such an accumulation of ice as we have been describing. A German gentleman, Herr Bernhard Bajohr, happened to be journeying from Nicolajew to Berislaw about the middle of December, when things were at their worst; and as the phenomena are seldom seen so fully developed, even in Russia, as they were at that time, it may be worth while to give some account of what he saw. His road lay between two telegraph lines; one the Indo-European, the other that of the Russian government, so that he had ample opportunity of observing and comparing the different effects produced upon the two. But, before describing these, we must say something as to the meteorological conditions required for the formation of this peculiar ice-incrustation.

In long-continued and severe frost, the earth is frequently chilled to a considerable depth, and to such a degree that it absorbs the warmth from the lowermost stratum of air, which becomes icily cold in consequence; while the trees, buildings, etc., within the cold stratum naturally share the surrounding temperature. This cold stratum may be from twenty to forty feet in thickness, while the air above is many degrees warmer. If rain fall from these warmer regions, though there will not be time for it to freeze during its short passage through the colder air, yet, directly it touches the ground or any other ice-cold substance, it will congeal and cover it, whatever it be, with a glaze of transparent ice, as noticed above. Herr Bajohr observed that, when the ice first began to form upon the telegraph wire, it was in the shape of a cylindrical roll, which instead of hanging from the wire, or being crystallized round it, as one would have expected, merely rested upon it, the wire touching its lower circumference only. As rain continued to fall, the cylinder increased in size, until its diameter measured from half an inch to three inches. This was the first stage of development; but then the intensity of the cold abated somewhat, and the rain which was still falling, instead of freezing the moment it touched the roll of ice, had time to trickle over it, and form long rows of icicles, remarkable for their regularity and uniformity. This was the second stage, and the heavily laden wires looked like nothing so much as gigantic combs.

It is not often that the third stage of development is reached; but it does sometimes happen that, when icicles and cylinder have attained their full size, the rain ceases, the sky clears, and the sun begins to shine. Its rays are much too feeble to melt the ice; but they pass through it to the more sensitive black wire within, whose temperature is so much raised that it melts the particles of ice in immediate contact with itself; its cohesion with the heavy roll of ice above is destroyed, and the latter, unable any longer to maintain its balance, twists round so as to describe a semicircle and exactly reverse its position. The icicles now stand up in the air above the wire, while the roll hangs below it; and, if there should be more rain, a second row of icicles will be formed opposite the first, producing a striking resemblance to the backbone of a fish, which is rendered still more perfect if there happens to be any wind blowing in the direction of the telegraph line, as in that case both rows of icicles will be slightly inclined toward the wire in the same direction. This last stage of development may also be attained without rain, should the sun have sufficient power to melt some of the ice; the water from which will then trickle down to the under-side of the roll of ice, and there form icicles in a similar manner. As the sun gains in power, the wire increases in temperature, and melts away more of the ice from within; the icicles, borne down by their own weight, drop lower and lower, until the wire reaches the extreme points of the upper row, when of course the whole congealed mass soon drops off.

Herr Bajohr noticed that the effect produced by this phenomenon on the two lines of telegraph differed considerably, that of the Russian government suffering far more than the other. The posts of the Indo-European line are of iron, and the conducting-wires are thick and strong; and, though the wire was considerably stretched, it had on the whole borne well the immense strain put upon it. Here and there, where the line made a bend, the post at the angle, firmly fixed though it was, had sometimes given way, and, wherever this was the case, several of the neighboring posts had also succumbed. But the government line, with its oaken posts and four thin wires, running parallel with the Indo-European line, presented a much more dismal appearance. The oaken posts, somewhat crooked to begin with, had not all proved strong enough to sustain the weight of the four heavily laden wires, and in some places had broken down altogether; while, where they remained erect, the wires were either broken, or completely weighed to the ground by the burden laid upon them. All the posts, both iron and oaken, were covered on the windward side with a crust of ice several inches thick, reaching from the ground to the insulators, where it joined the ice on the wires; and in this way insulation was destroyed, and each post was converted into a conductor, down which the electric current passed into the ground. This was especially the case directly the extreme severity of the weather abated and the ice became less dry. But the iron posts had this marked advantage over the wooden ones, that, whereas the latter kept their coating of ice for weeks, these others threw it off directly the sun began to shine. Being black, they absorbed heat more readily, and, by melting the inner surface of the ice, soon caused the whole to crumple up and fall off.

In conclusion, it remains for us to say a few words as to the effects of this remarkable frost-phenomenon upon the vegetable world. Trees are everywhere scarce in the steppes, their cultivation being attended with very great difficulty; nor is this to be wondered at when one considers the various climatic influences to which they are subject. During the winter of which we have been speaking, every tree, every branch, every smallest twig was incrusted with ice one, two, or three inches thick; and accordingly the trees in the town of Kherson, chiefly white acacias, lost nearly all their branches, while many of the smaller ones were completely crushed to the earth. Of the fruit-trees, all of which looked as if they were made of glass, some suffered more, some less, according to the character of their growth. The apple-trees and apricots for instance, with their spreading horizontal branches, were for the most part quite broken down; while the more erect-growing pear-trees and cherries had maintained their balance better and suffered much less in comparison.—*Chambers's Journal.*

SKETCH OF CARL RITTER.

CARL RITTER was born at Quedlinburg, in Saxony, the birthplace of Klopstock, on the 7th of August, 1779. His father was physician in ordinary to the Abbess of the convent in that place, and was a man of noble character and gentle disposition who was held in high esteem by his fellow citizens. He died in the prime of life and left his widow destitute, with five children, Carl being then five years old. The helpless situation of the widow, a well-born, refined woman, awakened general sympathy. Salzmann, who was about establishing a school for young children in Schnepfenthal, heard of it and determined to adopt Carl as a gratuitous pupil and as his first scholar. Carl found this a second home, and remained at the school eleven years, or until it was time for him to go to the university. It was in this lovely Thuringian town that, looking upon the manifold shapes of mountain and plain, wood and field, he received his first impressions of the relations which exist between the configuration of the earth's surface and the life that is developed on it. Modern languages and the arts and sciences were the more prominent subjects of study at the Schnepfenthal school, the classics receiving a secondary consideration.

While here, and with no definite prospects for his future after he should leave the school, Herr Hallneg, a partner in the wealthy house of Bethmann at Frankfort-on-the-Main, visited the institution at Schnepfenthal, and was so prepossessed by Ritter's appearance that he offered to support him while he continued his studies, on condition that he should engage afterward to teach in his house. So Ritter in his seventeenth year went to the University of Halle, and was matriculated as a student in branches relating to finance, in connection with which he gave especial attention to statistics. He made many friends while at the university, and at the age of nineteen went into Hallneg's house as a private tutor, and there formed a friendship with the youngest son of the rich merchant, his pupil, which endured through his whole life. Several distinguished men were accustomed to visit this house, and intercourse with them had such a stimulating effect upon the young teacher that his abode there may be regarded as having been in a certain sense a prolongation of his university career. Chief among these men was the naturalist Sömmering, whose geniality and liberal knowledge gave him great influence. Another was Alexander von Humboldt, who made a deep impression on Ritter's mind. Full of enthusiasm, Ritter wrote to his old teacher Gutsmuth: "It has now been eight days that I have enjoyed the happiness of being associated with Alexander von Humboldt. He is one of the most interesting men I have ever seen. It was my privilege to become acquainted with him on the first evening of his visit, and I have since enjoyed most precious hours in his society." At the same time Ritter was devoting himself to a diversity of studies, particularly to the pursuit of those branches, such as the classical languages and literatures, to which he had previously given a lesser share of attention. For this purpose he attended the gymnasium at Frankfort, and sat on the school-bench with his pupil Hallneg. His inclination toward geographical and historical studies did not, however, cease to preponderate; and, in order to make himself fully at home in these subjects, he not only read the most important works upon them with great care, but also made frequent excursions in the neighborhood of Frankfort for purposes of independent observation. A happy skill in drawing the objects of interest in the landscape was of great help to him.

His first geographical work, consisting of six maps of Europe, was published in 1806; it was followed in 1811 by a Geography of Europe in two volumes. These two works, his first efforts on a field in which he was afterward to be a master, already gave indications of that comprehensive grasp of geographical principles for which he afterward became distinguished.

In 1807, accompanied by his pupils, he started on the first of a series of journeys undertaken for purposes of study and investigation. This time he visited Italy and Switzerland. In Switzerland he formed the acquaintance of Pestalozzi, Pictet, and De Candolle, living in Geneva a year. In Italy he enlisted Thorwaldsen, Overbeck, and Cornelius among his friends. In 1813 he went with his pupils to the University of Göttingen, where he had an opportunity to make use of the treasures of the library for his great geographical work. He still regularly visited the lecture-rooms of the professors and attended the different colleges. After two years at Göttingen he went to Berlin, and there, in 1817, published the first part of his "Erdkunde im Verhältnisse zur Natur und Geschichte des Menschen, oder allgemeine Vergleichende Geographie als sichere Grundlage des Studiums und des Unterrichts in physikalischen und historischen Wissenschaften (Geography in Relation to Nature and the History of Men, or General Comparative Geography as the Secure Basis of Study and Instruction in Physical and Historical Knowledge), a work in which the treatment of geography was completely transformed, and the study was raised to the rank of a true science. This part included Africa and a portion of Asia. A year afterward appeared the second part, in which Asia was concluded. In this work he delineated the form and surface of the earth, in its horizontal and vertical features, with great accuracy. Taking a comprehensive view, he considered the peculiarities of the different parts of the earth's surface in their relations to each other and to the earth as a whole, and regarded them as the underlying basis of all living existence, and the foundation and condition of the development of single peoples and of the whole human race in its manifold changes of relation.

In 1819 Ritter was appointed Professor of History in the gymnasium at Frankfort; but he soon exchanged this position for a higher one, for in the next year he accepted an invitation to Berlin, where he was appointed to the chair of geography in the military school and the university. Here begins the second great division of his life, in which he could enjoy both in the department of scientific research and as a teacher the ripe fruits of his earlier activity. Berlin, where a new, fresh life was then beginning to beat, where he was associated with Alexander von Humboldt as his hearty friend, was the right place for him to work, and he was fully conscious of it. After Prince Albert became enrolled among his scholars, he was introduced to the circle of the Crown-Princes, and afterward to King Frederick William IV., before whom he gave lectures on geography. In 1825 he became director of studies to the Cadet corps, and in 1828 founder and first President of the Berlin Geographical Society.

Ritter was accustomed, during his autumn vacations, to take considerable journeys, which not only gave him mental and bodily recreation, but also assisted in the advancement of his geographical studies.

The most extensive and important of these journeys were to Greece and Constantinople, and back through Hungary; to Paris and Southern France; and to England, Sweden, and Norway. He afterward concentrated his whole attention upon geography, giving up for this purpose all employment that was not connected with it. From 1832 the series of volumes on Asia appeared in rapid succession; the nineteenth volume was finished only a few weeks before his death. With the progress of this work, his fame increased from year to year, and his connections and the influence which he exerted upon the progress of geographical research were extended to all the countries of the civilized world. He became one of the most important personal centers in the whole domain of geographical science, not less on account of the incomparable richness of his knowledge than on account of the living interest which he took in all current questions. In this position he did not fail to receive distinctions of every kind. As a teacher he acquired a brilliant clientage. When he published his first lecture on general geography in 1820, it is said that he had not a single scholar; afterward the largest lecture-rooms were not sufficient to hold his classes, and at Berlin it became the fashion to attend his lectures. As a teacher, and in all his personal relations, he possessed a strong attractive influence. Kramer, his biographer, says that no one ever approached him without meeting the most kindly reception, that he was ready to recognize every honestly meant effort, to encourage, to help with counsel and support. No man ever had less of egotism. His physical condition was generally good through the whole of his long life. He had a strong constitution, which was hardened by exercise in his youth and strengthened by the pedestrian excursions taken on his journeys. The weaknesses of age began to appear in his later years, and, on account of them, he often visited the springs of Teplich with good effects. He made a visit to these springs in 1859, the year of his death, but returned no stronger, and died on the 28th of September. After his death were published his "Geschichte der Erdkunde und der Entdeckungen," 1861; "Allgemeine Erdkunde," 1862; and "Europa," 1863.

CORRESPONDENCE.

Messrs. Editors.

IN a good but caustic review of Mr. Mallock's book—"Is Life worth Living?"—you make use of a sentence which would seem to reflect on all alike who are engaged in the study of theological problems: "We have here the last brilliant exploit of the theological mind in its warfare with modern science." Permit me, as a student of theology and a lover of modern science, to read you a short lecture. Many of the young ministers to-day are firm believers in evolution, and preach it. This theory is by no means a hindrance in our study of theology, but the best instrument which has so far been placed in our hands. If on our desk the Bible lies, so also do Spencer's "First Principles" and his "Sociology." If we respect and study Jesus, so do we Spencer and Tyndall and Clerk Maxwell. These have a gospel for us—they have a hope. The young theological mind is very far from engaged in a warfare with science; it is anxious, and hoping, for firmer ground than we now have. If science can help us, and it can and does, in making this life more valuable, the future brighter, and ourselves better, we welcome it. We are not troubled about reconciling theology and science; we take what we can in both, after honestly and carefully investigating for ourselves, and then allow them to reconcile themselves. What we have to do with is the truth pure and simple. Some of us will not pledge ourselves to any "body of divinity," either ancient or modern; we will not swear by Bibles, old or new, nor believe all the spirits, either in the Gospels or the biologies. The writer of the preface to the American edition of Spencer's "First Principles" tells us that his hope is in the young men. Many of them are with him. We now only ask you to remember this, and let us investigate in our own fields, mindful of the fact that we are each doing our best to find the truth. We are side by side oftener than we imagine, even if some college presidents will not see it. None are so blind as those who will not see.

It would not be out of place if in the "Monthly" you would give an article, now and then, bearing *directly* on the theological questions—the higher theological questions, not the petty disputes of the sects.

You have our hand.

A YOUNG THEOLOGIAN.

KEENE, N H., *January* 21, 1880.

THE AGE OF ICE

Messrs. Editors.

AN article under the above title, published in the October number of the "Monthly," appears to have brought upon its author the charge of plagiarism. But his own note with the accompanying editorial, published in the February number, not only completely exonerates him, but actually converts the charge into an encomium. For the writer of the article in question can scarcely fail to appreciate the compliment of being charged with borrowing, from so reputable an author, ideas which prove to have been made public before the able work of Mr. Croll had seen the light.

But, if the accusing party had carefully and understandingly read the article of Mr. Norton as well as those which he charges Mr. Norton with plagiarizing, he would never have made the charge. For he would have discovered in the former article statements quite excusable, when the date of their writing is known, but which would never have been made had Mr. Norton read either the work of Mr. Croll or the articles of Mr. Merriman. The object of the present writing, however, is neither to vindicate nor to criticise.

But, since the "Monthly" is almost solely relied upon by so many readers as an exponent of the latest scientific discoveries and opinions, the publication of Mr. Norton's article, so long after it was written, seems liable to mislead this class of readers. The conductors of the "Monthly" may not, therefore, deem it inappropriate to give place in their columns to a very brief statement of the points in which the article is likely to convey an erroneous impression:

1. In the published abstract the author says: "The southern hemisphere has at present a winter of 187 days and a summer of 179 days. We may justly infer that during this winter more snow and ice accumulate than the shorter summer is able to melt."

In the lecture this statement may have been accompanied by such an explanation as to prevent a misconception; but, as published, it must leave on the popular mind the impression that, because the summer is shorter, therefore the heat received from the sun is less—an impression which many have received; whereas it was long since shown that the earth receives from the sun exactly the same amount of heat from the vernal to the autumnal equinox as from the autumnal to the vernal, whatever may be the position of the apsides, and whatever the eccentricity of the orbit.

2. In speaking of the variation in the eccentricity, the author says: "There is one more factor in this problem which must be considered, and that is the periodical variation in the eccentricity of the earth's orbit. Sometimes the line of the apsides is longer than at other times."

I am at a loss to account for this last statement. The author must have known that the mean distance of a planet from the sun is one of the two invariable elements of the planetary orbits. Of course the line of the apsides, which is the major axis of the orbit, and therefore twice the mean distance, can not vary. The eccentricity is increased or diminished by diminishing or increasing the *minor* axis, the *major* axis remaining always the same.

3. In discussing the displacement of the earth's center of gravity by an accumulation of ice at the pole, it is said, "Now push the center of gravity 2,000 feet toward the north, and the Arctic Ocean would be so much deeper over the pole, and the water would be about 1,000 feet deeper at the latitude of 45°. To accomplish this result, we must calculate that the space within the Arctic Circle was covered by an ice-cap averaging, perhaps, 8,000 feet in thickness—an entirely supposable case."

By calculation, I find that, if all the water to form this ice-cap were taken from within the Antarctic Circle, and if the density of ice were equal to that of the earth, the above statement would be approximately correct; but, allowing for the difference of density, the cap must be more than eight miles in thickness; and, if the water to form the cap were taken equally from all parts of the earth's surface, the thickness must be more than sixteen miles.

Perhaps it should be said, however, that, according to Mr. Croll, no such amount of displacement is required. He estimates that the transfer of an ice-cap two miles thick from the southern to the northern hemisphere, which would displace the center of gravity about 380 feet, would satisfy all the demands of the glacial phenomena.

4. But, if Mr. Norton's article should be received as an exponent of the present views of those who advocate this theory, it would be most seriously misleading in the date to which it refers the *age of ice*. It is said: "Unless astronomical calculations fail, the last great summer of the northern hemisphere commenced some 6,500 years ago. When it began, northern America, Europe, and Asia were frozen and deluged. The Arctic Ocean extended to a line south of the present bed of the Great Lakes. The Alps and the Altai were also southern boundaries of this ocean. Europe was the home of a swarthy, dwarfish race, who hunted the aurochs and great hairy mastodon at the foot of the glaciers that then half overflowed the continent."

Thus the *age of ice* is referred to the last mild aphelion winter, when the earth's orbit was but slightly more eccentric than at present. But both Mr. Croll and Mr. Merriman, from whom Mr. Norton is accused of plagiarizing, refer the glacial epoch to a period of great eccentricity, from 80,000 to 240,000 years ago.

Indeed, the warmest advocates of the great year theory freely admit that, with the eccentricity no greater than it has been at any time within the last 80,000 years, the age of ice could not have been the reuslt of such a cause. It scarcely need be added that some refer the ice age to a period of still greater eccentricity, some 800,000 years ago

M. Lyford.

Waterville, Maine, *January* 26, 1880.

ARSENIC IN KINDERGARTENS.

Messrs. Editors.

There has been of late, in the local newspapers, a good deal of discussion, *pro* and *con*, concerning the merits and demerits of the Kindergarten system. Without presuming to decide whether the system is good or bad, I wish to bring under the notice of your readers a simple fact in connection with it that is of more than local interest. A friend of mine in Pittsburg, who has a little daughter being instructed (or amused) in one of the Kindergartens here, recently handed me some pieces of a green-colored paper which the child brought home from the institution, and told me that one of the amusements of children in such institutions was to cut figures out of various colored papers and fashion them into designs of different kinds, the aim of such amusements being to instruct in distinguishing various shades of color and differences of form. The green paper above mentioned I have very carefully examined, and I find that it contains an abundance of *arsenite of copper*, which most people nowadays know to be poisonous. In these days of reckless assertion by pretended men of science, it may be well to fortify my statement, and I accordingly send you two hermetically sealed tubes, one of which contains a mirror of *metallic arsenic*, and the other a ring of crystals of *arsenious acid*, both of them derived from the green paper, of which I also send you a sample. Several mirrors were obtained from a fragment of paper half the size of the piece inclosed, and material enough was procured from it to produce several more. The crystals can be recognized, under a three-hundred power of the microscope, as octahedra. Knowing well that such paper is used in all other Kindergartens throughout the country, and knowing also the habit of children putting everything available in their mouths, and especially of swallowing paper, I think the use of a sort colored with an arsenical pigment deserving of the severest reprehension. You may, if you please, show these tubes to any of the able chemists of your city, or describe them as you may see fit.

Yours truly,

GEORGE HAY, M. D., *Analyst*,

ANALYTICAL LABORATORY, 45 DIAMOND ST., ALLEGHANY CITY, PA., *January* 16, 1880.

EDITOR'S TABLE.

"*LET WELL ENOUGH ALONE.*"

A GOOD illustration of the tendencies of officialism in education, as well as in politics, is afforded by the recent inaugural address of the new President of the New York Board of Education, Mr. Stephen C. Walker. He said he had formerly been opposed to the policy of taxing the people to sustain academic or high-class education. But no sooner does he find himself in the official saddle than all doubt is dissipated, and he becomes the eager apologist of things as they are. And this is the more remarkable, as he betrays a lurking consciousness that there is a good deal hereabout that will not bear examination, and of which the less is said the better. He admonishes some people that they had better have a care, and not push things much further, as there may come a day of reckoning. Therefore he urges quiet and acquiescence, and deplores all excitement and agitation. A certain questionable policy being consummated beyond what its promoters could have ever dreamed, he thinks the rule should be now, "Let well enough alone." Mr. Walker is reported as saying: "We not only have two colleges, whose expenses are met by general taxation, with *curricula* embracing every known subject of academic instruction, but, in the course of study of our grammar and primary schools, the subjects presented number fifteen or twenty, and, of course, embrace many which are neither essential nor elementary. Never having been able to give full assent to the arguments which are claimed to prove the propriety of making academic education a public charge, I am ready, and even eager, to accept the present situation of affairs, and to say to the champions of what is called higher education, and to the less eloquent and active advocates of elementary instruction, let well enough alone. I foresee dangers in agitation and disturbance. I see much good in things as they are. If those who sincerely believe that the Government should be so parental and munificent as to place within the reach of every aspiring lad the means of the most ample technical or professional education will only rest content with the large measure of success they have already gained, with the crowded seats of advanced learning endowed beyond all dreams of private munificence, by legislation, which subsidizes for their support the property, real, personal, and mixed, of the whole Commonwealth, they will not hazard the attainments already made. In pushing for more there is, in my judgment, a possibility of arousing a power in the community, of great weight by reason of its wealth, its clear judgment, its conservative and logical methods, which shall bring all the force of argument and capital against the existence, at public expense, of academic education in any form."

Having got two colleges, embracing every known subject of academic instruction, and grammar-schools devoted to fifteen or twenty subjects which are neither essential nor elementary, and endowed beyond all dreams of private munificence by legislation which subsidizes for their support the property, real, personal, and mixed, of the whole Commonwealth, for all of which he has never seen sufficient reason, Mr. Walker thinks we may now rest and be thankful. There have been demands that something should be done to make education more practical in the direction of applied science and industrial art. But Mr. Walker says: Be quiet; these things can only come in with a popular boom. This is his language: "It may be that, as a result of one or all these demands, we shall see the time when the turning-lathe and the sewing-machine shall be parts of general school supplies. The point I make is, that agitation and discussion of this subject are not incumbent upon us, who are called to administer the school system as we find it, not to revolutionize its fundamental principles or work experiments. When the time comes for such changes we shall all hear of it. It will be a voice as of the sound of many waters. The school system and its methods and subjects of instruction are surrounded by almost constitutional guarantees. The people created and cherish this system and these methods and the existing modifications thereof." Now, we respectfully suggest that, if President Walker proposes to keep things placid, he must be a little more circumspect in his statements, and not give occasion for indignant protest. It is not true of the school system under his jurisdiction that the people created it "and the existing modifications thereof." Those "modifications" were never called for or authorized by the people. The school system of New York has been revolutionized and perverted from its original purposes, and that not by popular initiation and approval, but by manœuvring and indirection, by wire-pulling and huggermuggery. It has been prostituted to ends never contemplated by those who established it and have sustained it, and this has been done in express defiance of the known convictions and wishes of the people. President Walker probably knows this, and hence his apprehension of a popular explosion, and his exhortations to a cautious and gingerly treatment of fundamental questions. On the contrary, we think the subject can not be too often and too thoroughly ventilated.

The reader is referred to a previous article in this "Monthly," which shows that the New York school system was founded to supply elementary instruction to those unable to obtain it in preexisting schools. But, with the progress and diffusion of knowledge, and especially of practical scientific knowledge that bears upon the common avocations of life, there grew up a popular demand that our common-school system should do something to qualify boys for industrial pursuits. To give effect to this widely expressed desire, it was proposed to establish in connection with the public-school system a high school of technology and practical science, to help boys who were expected to learn trades and follow industrial occupations. It was submitted to a popular vote whether such an institution should be organized, and its distinctive and limited object was printed upon each ballot. The people pronounced by a large majority in its favor, and the "Free Academy" was the result.

But the object of this institution was never honestly carried out. Its faculty were ashamed of its vulgar "utilitarian" purpose; a "Free Academy" had no status among dignified institutions, and its officers did not cease their exertions till its object was abandoned, and the concern was transformed into a "regular college." The Free Academy was killed, and a new charter was obtained, instituting the "College of the City of New York."

With this "modification thereof"

the people had nothing to do. They were never offered a chance of expressing their opinion of the repudiation of the plan they had formally ratified. It was diverted from its objects, without consulting them, by ring-management; and, as the city had got a college for boys, the cry was raised that there must be another for girls also; and the Normal College was the result.

There was no mistaking the character and object of this covertly managed revolution in the policy of popular education in this city. When the thing was done, all disguise was thrown off. As we have stated before in these pages, but which may now be pertinently recalled, Judge Larrimore, President of the Board of Education, gave an address explanatory of the new situation. The school called for by the people was contemptuously repudiated in its theory and object. The new institution was proclaimed as of the old order of colleges. The speaker went back to the middle ages to get his ideal of a college, and defended classical studies, as entitled to the leading place, in opposition to the claims of science and modern studies. How far he appreciated the idea which the people had tried to embody in the Free Academy was shown by the fact that, when an influential work on education, that has been translated into all civilized languages, was quoted, he sneeringly retorted that it was written by an *engineer*.

Had the design of the Free Academy been carried out in good faith, its benign results to education in this city and this country would have been great. A generation has passed since the people pronounced for an advance in industrial education; and if the plan had not miscarried—if they had not been cheated out of it—the salutary influence upon the lower schools, and the consequent benefits to the community, would have been incalculable. But this retrogressive step has been fatal to our educational progress. The classical college at the head of our system has reacted to obstruct reform in the primary schools. Of the way this influence is exerted we have a fresh illustration. The new President, notwithstanding his solicitude to let things alone, can not refrain from meddling. He was made chairman of the Board of Trustees of the City College, and in his address he said that "the college entrance examinations were not exacting enough." That is, the screws must be put on to the lower schools to force more vigorous exertion on the part of boys with reference to the system of instruction pursued in the classical institution.

CONANT ON INTERNATIONAL COPYRIGHT.

It is surprising how English ardor on international copyright cools as Americans begin to draw the distinction between the rights of British authors and the claims of British publishers. As long as these were mixed up, the case against us was strong, and we were very frequently reminded of the turpitude of our piratical practices. But when it began to be said here, seriously, We will yield the English author his just demand, and pay him for his literary property, but his foreign publisher we will not pay because he has no just claims upon us, then we hear a good deal less of foreign denunciation, and international copyright ceases to be urged, or much discussed.

Mr. S. S. Conant, of New York, was asked to write a paper for "Macmillan's Magazine," giving the American view of the subject. He complied, and furnished an able article, moderate but decided, and discussing the question with a view to its practical settlement. He recognized the urgency of the question, and took the ground that the full rights of English authors should be accorded and secured by law, but that we in this country must be permitted to manufacture their books. He showed that the foreign book-maker has no rights that such an arrangement would violate, and that equity would be completely gained if the foreign author was required to make his bargain with some American publisher. There are American reasons for this policy, the force and validity of which Americans must be left to judge of; but justice will be satisfied when the foreign author is put upon the same basis as the American author.

A reply or at least a rejoinder to this article, by an English lawyer, followed it in the same number of the Magazine. Mr. Conant had said that the need of some adequate copyright arrangement between the two countries was pressing; his critic undertook to be very sarcastic at this, declaring that leading American publishers were now beginning to suffer from the carrying out of their own vicious system, and had suddenly discovered that the case is pressing. He said that he saw no particular symptoms of urgency in England, and doubted if the Americans were very eager about it, so that on the whole the matter might as well be at present let alone.

Mr. Conant returned a crushing reply to his critic, but "Macmillan" declined to print it. It, however, appeared in the London "Academy." He showed that the quibble over the word "pressing" was aside from the argument, and that that term simply indicated the actual status of the question in both countries. If business had become more demoralized here, under a bad system, than before, it only furnished a more potent reason for remedial action. No change certainly had taken place on this side of the water which could lessen the interest of the British author in international copyright. On the contrary, the system in this country was working out results more and more damaging to foreign authors. As to the state of feeling in England, Mr. Conant showed that her authors at any rate did not share the assumed indifference of "Macmillan's" critic. He showed that the recent Royal Commission relating to home, colonial, and international copyright, gave prominent and earnest attention to the relations of England and the United States with regard to authors and reprints, and that their report bristled with evidences of the interest felt in that country over this question. And, finally, he clinched the case by putting in the recent statement of fifty eminent English authors, not only recognizing the importance of the question, but accepting the American view of it, and expressing their readiness to acquiesce in it as an entirely fair and just arrangement.

So the tables are now turned, and the English publishers, who oppose a measure satisfactory to the parties rightly interested there, and which is the only practical measure that can possibly be carried out here, are now in the position of obstructives, and enemies of copyright. Mr. Conant's pamphlet puts the thing in a nutshell, and those concerned with the progress of the discussion can obtain it by application to Harper & Brothers, New York.

LITERARY NOTICES.

SPENCER'S SYNTHETIC PHILOSOPHY.

Ceremonial Institutions. Being Part IV. of "The Principles of Sociology." By Herbert Spencer. Pp. 237. Price, $1.25.

Having paused for a short time in the elaboration of his "Principles of Sociology" to anticipate a portion of the next treatise on "Ethics," Mr. Herbert Spencer has resumed his labors in their regular order, as the volume before us attests. The first volume of the "Sociology"—a work of over seven hundred pages, devoted to its fundamental data and inductions—was published more than a year ago. Mr. Spencer finds serious disadvantages in bringing out his system in these large volumes, which are both formidable to read and appear at such wide intervals that their connections are apt to be forgotten. He will, therefore, in future, issue separately the successive divisions of these volumes as they are completed. The first division of Volume II. is on "The Development of Ceremonial Institutions," now published, and the next division will be on "The Development of Political Institutions," and upon this he is now engaged. It will be followed by the divisions on "The Development of Ecclesiastical and Industrial Institutions."

If we define government as the control of conduct in relation to others, then it is of two kinds—that by the coercion of the civil power, and that by the mandates of social custom and ceremonial observance. The regulation of conduct is divided between civil law and the unwritten codes of custom; and of these two authorities the latter has by far the largest share in regulating men's lives. In the genesis of social relations, ceremonial government arises earlier than political government, is more general, and far more potent in its social restraints and requirements. While yet primitive society is in a wholly unorganized condition, with no coercive rule, perhaps, but the will of the chief, the savage nature becomes spontaneously amenable to imperative observances in daily intercourse. And, in the highest state of civilization, social life is dominated by the same despotic agency. To understand the present constitution of society, therefore, and the forces by which it is regulated, it becomes necessary to treat the origin and growth of social observance as a part of sociological science, and this is the object of the volume on "Ceremonial Institutions."

Mr. Spencer's conclusions throughout rest upon a wide survey of the facts concerning primitive customs and manners, gathered from all sources, and are illustrated with a wealth of examples that gives great force and impressiveness to his conclusions. This very full and complete illustration of the subject has been objected to by some, on the ground that such a profusion of facts and examples is unnecessary to his exposition, and becomes wearisome to the reader; and the same criticism has been passed upon other parts of his philosophical works. To this he replies, in his preface, that, while not unconscious of the defect, it is still unavoidable, as scientific proof rather than artistic merit is the end he is aiming at. He says: "If sociological generalizations are to pass out of the stage of opinion into the stage of established truth, it can only be through extensive accumulations of instances; the inductions must be wide if the conclusions are to be accepted as valid. Especially while there continues the belief that social phenomena are not the subject-matter of a science, it is requisite that the correlations among them should be shown to hold in multitudinous cases. Evidence furnished by various races in various parts of the world must be given, before there can be rebutted the allegation that the inferences drawn are not true, or are but partially true. Indeed, of social phenomena more than all other phenomena, it must, because of their complexity, hold that only by comparisons of many examples can fundamental relations be distinguished from superficial relations."

Some of the chapters of the volume on "Ceremonial Institutions" have appeared in the pages of this Monthly, but several new and important topics are treated in the volume, which make it the completest as well as the most original discussion of the subject that has yet appeared. It is, besides, an extremely interesting book to read, as it gives much curious information regarding the origin and meaning of social usages that concern everybody, while at the same time there is no erudite or abstract philosophy in it to task the reader's effort.

The Theory of Political Economy. By W. Stanley Jevons, LL. D., M. A., F.R.S. London: Macmillan & Co. Second edition. Pp. 314. Price, $3.50.

The above work presents, in the most complete form yet given it, Professor Jevons's mathematical theory of economics, first published by him in a volume nine years ago, though worked out and presented in its main features as far back as 1862. The idea that economics is essentially a mathematical science appears not to be new, but, during the ascendancy of other views, it has for the most part been neglected, and the work accomplished remained in obscurity.

Professor Jevons has been at some pains to investigate the bibliography of the subject, and finds it surprisingly full and of considerable value.

It appears from his researches that the theory, as stated by him, and in a form closely resembling his, by M. Léon Walras, of Lausanne, has been anticipated in its chief features by Gossen, of Germany, and Cournot, of France. This is somewhat remarkable, as these writers worked not only independently of each other, but with little or no knowledge of what had been done by any others. They had, in fact, to begin at the beginning and work out the entire subject for themselves. Professor Jevons regards this independent arrival at substantially the same views of the "fundamental ideas of economics," by four different inquirers, as strong evidence of their probable truth. He appends to the present edition of his work a fuller list than was possible in the first of all the writers whose names he has been able to discover, who treat the science on this side, that future students may not remain in ignorance of what has been accomplished.

The present unsatisfactory state of economics is regarded by him as due to the failure, on the part of economists, to distinguish between several branches of knowledge which, though closely allied, are yet separate. There should be a distinction drawn between the abstract science which has to do with the fundamental relations of economic quantities and those special concrete sciences which depend upon it. The relation of this abstract science to the concrete ones he holds to be somewhat analogous to that between the science of mechanics and the physical sciences, all of which have their basis more or less in it. Pleasure and pain are, according to him, the ultimate factors with which economics has to deal, and how to increase the one and decrease the other to the greatest extent possible is the problem to be solved, or, stated more specifically, the problem is: "Given a certain population, with various needs and powers of production, in possession of certain lands and other sources of material; required the mode of employing their labor which will maximize the utility of the produce." In order to subject the science to his analysis, Professor Jevons introduces into economic quantities the physical conception of dimension. These quantities can then be treated geometrically, and their various relations expressed by formulas. A feeling, such as a pleasure or a pain, he considers possessed of two dimensions, intensity and duration, the amount of which can be varied by varying either or both of the factors. A curve whose ordinates correspond with the intensity of the feeling and the abcissas with its duration will express the law of the variation of the intensity, when this variation is continuous.

The relations of the various economic quantities involved would, in any case, be known when the elements of such a curve were determined, or, as the mathematicians say, when the form of the function is known. The agreement of the calculated result, when numerical data are introduced into the formulas, with the actual result, would be the verification of the formulas. Such numerical data, consisting mainly in "accurate accounts of the quantities of goods possessed and consumed by the community, and the prices at which they are exchanged," are not now easily attainable, and formulas can not, therefore, be at present verified. As these data become available, however, Professor Jevons thinks that the science can gradually be raised to the position of an exact one.

A large portion of the present work is devoted to the elucidation of the problem of exchange value, which is necessarily fundamental in any economic exposition. Exchange value, or, as he terms it, "the ratio of exchange," is held by him to be directly dependent upon utility and only ultimately upon cost of production. In his theory of utility he draws a distinction between the total utility of any commodity and its degree of utility at any point of supply, the person concerned being the sole judge in any case considered of what is or is not useful. In illustration, the total utility of such a thing as food is infinitely great, as it is necessary to life; but, when we have abundance, the utility of an addition is very small and may be zero. Considering the increase of supply to be made by adding increments of commodity, the degree of utility of the last increment added, or of that to be added, he terms the final degree, and it is on this that the ratio of exchange depends. He finds the explanation of the fact that such a very useful commodity as water has little or no power in exchange in the circumstance that its final degree of utility is ordinarily very small. When water becomes scarce the higher degrees of utility are approached, and, if the scarcity is prolonged, it may acquire a high purchasing power. Geometrically, total utility would correspond with the area inclosed between a curve and its lines of reference, and the degree of utility at any point with the ordinate of the curve at that point. His conception of utility corresponds closely with that as expressed in ordinary language, the total utility being the entire usefulness of any commodity, the degree of utility the esteem or urgency of desire, and the ratio of exchange the purchasing power.

As viewed by Professor Jevons, the problem of exchange is properly a dynamic one. Commodities are being continuously manufactured, exchanged, and consumed. The solution of the problem, therefore, involves determining not only the conditions of equilibrium at which exchange would cease, but the rate at which it would go on before equilibrium was established. The statical problem—the obtaining of the conditions of equilibrium—is only attempted in the present work. He considers that the parties to the exchange are possessed of certain fixed quantities of commodity which they keep exchanging until the point is reached when they are satisfied, and have no further desire to part with or acquire any more. His analysis brings him to the conclusion that "the ratio of exchange of any two commodities will be the reciprocal of the ratio of the final degrees of utility of the quantities available for consumption after the exchange is completed."

The usual treatment of labor by economists Professor Jevons regards as singularly perverted. The science starts with labor, and how to use this labor to the greatest advantage is the very problem with which it deals. But economists generally do not proceed far before they turn about and consider labor as a commodity which capitalists buy up. "Labor becomes itself the object," he says, "of the laws of supply and demand, instead of those laws acting in the distribution of the products of labor." His conclusion is that "the wages of a working-man are ultimately coincident with what he produces, after the deduction of rent, taxes, interest, and the interest of capital." According to his analysis, when in any case of production the labor is distributed, the ratio of the final degrees of utility of the products equals the ratio of the productiveness of the labor concerned in each product. He thus arrives at the result that the ratio of exchange is ultimately determined by the cost of production, through the effect which this has in determining the final degrees of utility of the commodities. The conclusions of the work, on the subject of exchange, Professor Jevons sums up as follows: "Quantities of commodity exchanged vary directly as the quantities produced by the same labor, and inversely as their values, prices, costs of production, and final degrees of utility."

Professor Jevons accepts the current definition of capital, though he broadens it somewhat, and his analysis of the subject leads him to conclusions closely agreeing with those of Ricardo and the economists who have followed him.

The doctrine of rent he regards as having long been in a scientific form.

Of the value of the theory, both as to what is obtained and as to its possible development as a comprehensive treatment of economics, it is for economists to decide, but it can be studied with interest and profit by all who desire to know one of the directions in which present economic inquiry is tending. The book is written in the clear manner peculiar to all the work of this author, and can be readily perused by any one having the slightest knowledge of the calculus.

The Chemistry of Common Life. By James F. W. Johnston. New edition, and brought down to the Present Time by A. H. Church. New York: D. Appleton & Co. 1880. 1 vol., pp. 592. Price, $2.

A revised edition of this favorite work, first issued twenty-five years ago, will be welcomed everywhere. It has ever been the model of a popular scientific work, and has had many imitations—notably, Lewes's

"Physiology of Common Life"—but none of them have approached the perfection of the original. Johnston was led to prepare it by his pioneer studies in agricultural chemistry, which not only familiarized him with all common subjects, but, what was of far more importance, gave him a sympathetic interest in the common people. No mere passionate experimenter or laboratory devotee could ever have produced such a work. Great changes have come over the field of chemical science during the last quarter of a century, but they have affected this work much less than more theoretical treatises, as facts change less than their interpretations. Nevertheless, the book had fallen behind the age, and needed to be brought up to date. The entire work has been carefully revised by Professor Church, somewhat enlarged, and brought down to the latest date. Some new matter, aside from that necessary to embody the latest knowledge, has been added by the editor, the most important of which is the article upon "The Colors we admire." The book is written for the people, in a clear and popular manner, without technicalities, and seeks to answer questions that commonly arise in every-day life about every-day things. It treats such things as the air we breathe and the water we drink in their relations to human life and health; the soil that we cultivate and the plants raised; the food we eat and beverages we drink; the odors that are agreeable and disagreeable, and the reasons why they are so; the colors that stand in like relation to us; the physiological processes of the body, and the condition of health. It answers, in fact, a thousand and one questions which all ought to know, but which they do not, and will be found a valuable addition to the library of every household.

Astronomy. For Schools and Colleges. By Simon Newcomb, LL. D., Superintendent of "American Ephemeris and Nautical Almanac," and Edward S. Holden, M. A., Professor in the United States Naval Observatory. New York: Henry Holt & Co. Pp. 512. Price, $2.50.

The presumptions in favor of this work, which are created by the names of its authors, are abundantly justified by its critical examination. It may be commended as in every respect a first-class astronomical textbook for college students. The authors say in their preface that "the work is designed principally for the use of those who desire to pursue the study of astronomy as a branch of liberal education." Yet its plan is such that it may subserve the uses of different grades of students, and those having in view quite different objects. The subject-matter is divided into two classes, distinguished by the size of the type. The portions in large type form a complete course for the use of those who desire only such a general knowledge of the subject as can be acquired without the application of advanced mathematics. This is the part that will interest the general reader. The portions in small type comprise additions for the use of those students who either desire a more detailed and precise knowledge of the subject, or who intend to make astronomy a special study. The work is copiously illustrated, is written with great clearness, and its explanations are admirable.

Progress and Poverty. An Inquiry into the Cause of Industrial Depressions, and of Increase of Want with Increasing Wealth; the Remedy. By Henry George. One Volume. New York: D. Appleton & Co. 1880. Pp. 512. Price, $2.

In the previous pages of this Monthly the reader will find an article on the "Study of Political Economy" that will be pretty certain to interest him. He will see that this so-called "dismal science" is capable of being presented in an attractive way. But after looking it over with satisfaction, as he will be sure to do, he may still say: "This man puts the subject very pleasantly in a lecture, but where are the treatises which can realize for us the interest of treatment here promised? All the books I have yet found on this topic are very prosy affairs."

Well, the author of this essay has himself made a book on political economy, so that he can be tried by his own test. He has made a pretty big book too (although it is not expensive), and, whatever may be its faults, dryness and dullness are not among them. It is full of vital thought, and is written with earnestness and power. We might say it is the most engaging book on economical subjects that we have ever read, but some may think that is not saying much, after all; and so we will add that it is a work hard to lay down when once begun.

The author is a man of marked intellectual power, of independent convictions, and of strong human sympathies. He lives in San Francisco, where he has been for thirty years, watching the growth of society in a forming State. He has observed the working of the forces by which a modern community has grown up from a rough and formless to a settled, organized, and advanced condition.

The outcome of all this immediate observation and of the extensive study of the conditions of other communities is the conviction that the imminent problem of the age is the intimate association of progress and poverty. The persistence of poverty amid rapidly advancing wealth is a widely recognized and deplorable fact, which has impressed itself more and more strongly upon thoughtful people. This century has been characterized by an enormous increase of productive power and an immense multiplication of riches. But this increasing wealth has neither been equalized throughout the population, nor has there been any tendency to equalization. The gulf between rich and poor has been widening, and neither the rapid strides of invention nor the enormous development of the labor-saving and the wealth-creating arts has been able to arrest this widening.

Mr. George says: "The association of poverty with progress is the great enigma of our times. It is the central fact from which spring industrial, social, and political difficulties that perplex the world, and with which statesmanship and philanthropy and education grapple in vain. From it come the clouds that overhang the future of the most progressive and self-reliant nations. It is the riddle which the Sphinx of Fate puts to our civilization, and which not to answer is to be destroyed. So long as all the increased wealth which modern progress brings goes but to build up great fortunes, to increase luxury, and make sharper the contrast between the House of Have and the House of Want, progress is not real and can not be permanent. The reaction must come."

Again he says: "I propose in the following pages to attempt to solve by the methods of political economy the great problem I have outlined. I propose to seek the law which associates poverty with progress, and increasing want with advancing wealth; and I believe that in the explanation of this paradox we shall find the explanation of those recurring seasons of industrial and commercial paralysis which, viewed independently of their relations to more general phenomena, seem so inexplicable. Properly commenced and carefully pursued, such an investigation must yield a conclusion that will stand every test, and, as truth, will correlate with all other truth. For in the sequence of phenomena there is no accident. Every effect has a cause, and every fact implies a preceding fact."

Now, in a brief notice like this we can neither give, nor attempt to give, Mr. George's solution of his problem. But we may say he finds it in the land question, and its remedy in a very radical and thorough reforming of our land policy. We do not here endorse Mr. George's work, but we very strongly recommend it to those who take interest in the living questions of the time. We hope soon to give a sketch of his argument, but no outline can do it justice. We may add that, aside from his special discussion, the book abounds in information on economical principles and facts admirably put, and which will well repay perusal.

Lectures and Essays. By the late William Kingdon Clifford, F. R. S. Edited by Leslie Stephen and Frederick Pollock. With an Introduction by F. Pollock. In Two Volumes. With Two Portraits. New York: Macmillan & Co. Pp. 661. Price, $7.50.

Clifford has been so thoroughly sifted, and his position as a thinker is so well known, that little needs here to be said upon this point in introducing his essays to the reader's attention. But the massing together of his intellectual work will heighten his fame. For only when his brilliant and powerful disquisitions are brought together, so that we can compare them and discern their variety and scope, is it possible to do justice to his genius. That he was a transcendent mathematician most readers can only recognize by what others say, but the essays can be judged by all who are capable of thinking. The feature that strikes us most in reperusing these volumes, and to which we have before called attention as a characteristic of his writings, is the mastery they display of the art of luminous exposition in dealing with obscure and abstruse subjects. Here Clifford is quite incomparable, and there are parts of these volumes which will long survive as models of popular statement, delightful to the reader from their vividness and marvelous lucidity. Clifford is at his best in disentangling and laying out to view subjects which baffle ordinary grasp and penetration. He may be said to make perfectly clear things which ordinary people complain that they can only partially and imperfectly understand. To take a random example, we open volume one, and happen to strike, in the middle of it, a discourse upon atoms. This might be at once taken as a crucial test of Clifford's power of picturing by language. Everybody knows something about atoms, and everybody is bewildered in the attempt to form such a conception of them as will explain the mutual influences and interactions of the material bodies which are composed of atoms. Turning to the beginning of this lecture, which was a popular effort in a Sunday course, we find him thus opening his subject

If I were to wet my finger and then rub it along the edge of this glass I should no doubt persuade the glass to give out a certain musical note. So, also, if I were to sing to that glass the same note loud enough, I should get the glass to answer me back with a note.

I want you to remember that fact, because it is of capital importance for the arguments we shall have to consider to-night. The very same note which I can get the tumbler to give out by agitating it, by rubbing the edge, that same note I can also get the tumbler to answer back to me when I sing to it. Now, remembering that, please to conceive a rather complicated thing that I am now going to describe to you. The same property that belongs to the glass belongs also to a bell which is made out of metal. If that bell is agitated by being struck, or in any other way, it will give out the same sound that it will answer back, if you sing that sound to it; but if you sing a different sound to it then it will not answer.

Now, suppose that I have several of these metal bells which answer to quite different notes, and that they are all fastened to a set of elastic stalks which spring out of a certain center to which they are fastened. All these bells, then, are not only fastened to these stalks, but they are held there in such a way that they can spin round upon the points to which they are fastened.

And then the center to which these elastic stalks are fastened or suspended you may imagine as able to move in all manners of directions, and that the whole structure made up of these bells and stalks and center is able to spin round any axis whatever. We must also suppose that there is surrounding this structure a certain framework. We will suppose the framework to be made of some elastic material, so that it is able to be pressed in to a certain extent. Suppose that framework is made of whalebone, if you like. This structure I am going for the present to call an "atom." I do not mean to say that atoms are made of a structure like that. I do not mean to say that there is anything in an atom which is in the shape of a bell: and I do not mean to say that there is anything analogous to an elastic stalk in it. But what I mean is this—that an atom is something that is capable of vibrating at certain definite rates; also that it is capable of other motions of its parts besides those vibrations at certain definite rates; and also that it is capable of spinning round about any axis. Now, by the framework which I suppose to be put round that structure, made out of bells and elastic stalks, I mean this—that supposing you had two such structures, then you can not put them closer together than a certain distance, but they will begin to resist being put close together, after you have put them as near as that, and they will push each other away if you attempt to put them closer. That is all I mean, then. You must only suppose that that structure is described, and that set of ideas is put together just for the sake of giving us some definite notion of a thing which has similar properties to that structure. But you must not suppose that there is any special part of an atom which has got a bell-like form, or any part like an elastic stalk made out of whalebone.

A large part of these essays is devoted to the discussion of the moral and religious problems which so prominently occupy the speculative attention of the age. These subjects are all handled with the author's customary originality and felicity; but it is impossible here to give any account of them. He attempted no system, and his work must be looked upon as consisting of elaborate fragments, valuable for what they are separately worth. We quote a portion of the criticism passed upon him by the London "Spectator":

The late Professor Clifford was a meteoric sort of moral phenomenon, who to many, even of those who had some personal knowledge of his extraordinary powers, was more of a bewilderment than a light. He was a man of rare wit and rare powers of fascination, of extraordinary courage and extraordinary agility, both physical and mental, very great kindliness and very great audacity, enthusiastic disinterestedness and almost measureless irreverence. He was a great master of gymnastic, who, when he came out second wrangler at Cambridge, was much prouder of being mentioned in "Bell's Life" as a great athlete than of being second wrangler. "His nerve at dangerous heights," wrote a friend who was his rival in gymnastic feats, "was extraordinary. I am appalled now to think that he climbed up and sat on the cross-bars of the weather-cock on a church-tower; and, when, by way of doing something worse, I went up and hung by my toes to the bars, he did the same." During a journey in France, when the boat had left the quay at Havre, Clifford, arriving late, jumped on board of it, "with one of those apparently unpremeditated springs which look so well in the gymnasium." His flexibility and complete command of his own powers, both of mind and body, were probably as great as any human being ever possessed. And as he seems to have been entirely free from anything like giddiness in his gymnastic feats, so he seems to have been equally free from anything like awe in the equally marvelous gymnastic feats of his mind, treating the infinity and eternity in which his fellow creatures believed with the same sort of contemptuous familiarity with which he treated the ecclesiastical height he had once reached, only to balance himself by his toes on the weather-vane. He speaks, indeed, in the least irreverent of his antitheistic papers, of having parted from his faith in God "with such searching trouble as only cradle faiths can cause." And no doubt he must have felt something which entitled him to use this language, for Clifford was sincerity itself. Nevertheless, this is almost the only passage we have met with which points to his having gone through any crisis of the kind, while there are a great many in which he treats the faith in God with such utter, such cold contempt, that it is not easy to understand how he could ever have regarded it as being the light of his light and the life of his life, and much less how he could have realized that other men were still so regarding it, while he was launching his satire at them. In such a passage as the following, for example, he seems to be trying to show that he was as reckless of the awe which the faith in God and eternal life generate, as when, hanging with his toes on the church-vane, he was reckless of the fears which such a position as his would impart to most men: "For, after all, such a helper of man outside of humanity, the truth will not allow us to see. The dim and shadowy outlines of the superhuman deity fade slowly away from before us; and, as the mist of his presence floats aside, we perceive with greater and greater clearness the shape of a yet grander and nobler figure—of Him who made all gods, and shall unmake them. From the dim dawn of history, and from the inmost depth of every soul, the face of our father Man looks out upon us with the fire of eternal youth in his eyes, and says, 'Before Jehovah was, I am.'" We transcribe the words of this parody with reluctance, and something almost of shame, but still with the feeling that they are essential to the understanding of the erratic man who wrote them, and who never could have written them if he had not been strangely deficient in those many fine chords of sympathy with his fellow men which in other skeptics like himself remain vibrating, and securing for them a certain community of sentiment with their fellows, long after the sympathy of conviction, necessary originally to agitate them to their full extent, has vanished. Doubtless, Clifford held all moral conventionality in utter horror. As he once told an audience, in face of the great danger which threatens nations that they may crystallize, like the Chinese, into inflexible habits of thought and feeling which would shut them out from progress, "it is not right to be proper." But still such a parody as we have quoted on what is to so many men the most sacred of human utterances, one indeed embodying the most solemn passion of conviction through which the heart of man has ever passed, would not have been, in most men's mouths, so much a violation of propriety as a deliberate insult to the heart of multitudes. That Professor Clifford did not so regard it seems to us quite evident. But that only shows how curiously destitute he was of some of those chords of sympathetic feeling, without the help of which it is impossible to judge with any adequacy the moral world in which you live. And with all his wonderful talent for society, and that extreme kindliness of his nature which so fascinated children, Professor Clifford certainly showed signs of a curious nakedness of the finer moral sympathies, a nakedness diminishing in great degree both the impression of cruelty which the mordant and contemptuous character of his attacks on religion would otherwise make upon us, and also, in some degree at least, the intellectual weight to be attached to his undoubted genius when it worked upon subjects of this kind.

An Essay on the Bible Narrative of Creation: Genesis I.–II. By Professor A. R. Grote. New York: Asa K. Butts.

What to do with the first chapters of Genesis has long been a perplexity with those who hold it to be a veritable account of the origin of the universe, and who at the same time accept the conclusions of modern science on that subject. Differences are confessed and great ingenuity has been expended in reconciling them. In a thin volume of eighty-two pages Professor Grote gives us the results of his study of the question. He gives two versions side by side, the Hebrew text in English letters, together with the translation. Then follows a chapter on "Literary Criticism." In this the writer follows the researches of Ewald and Kuenen with regard to the name of the Deity. He makes use in his translation of the terms "Elohim" and "Yahveh Elohim," because the words "God" and "Lord God" do not translate the Hebrew correctly, the plural form of Elohim being lost in the English word "God," which is a substitute for and not a translation of the Hebrew term Elohim. Another important deviation of Professor Grote's translation from the King James version lies in the fact that the word *ha-Adam* is constantly translated "the man" throughout, whereas the authorized version from Genesis ii. 19 to the end of the creational history of the first man uses the proper name "Adam," the Hebrew remaining the same as before. The author shows that the two chapters can not be considered as a continuous narrative, the first account ending at chapter ii. 3, and the second commencing chapter ii. 4. The descrepancies between the two accounts are very fully indicated, and the different points of view from which they were written explained.

The author then gives a chapter on the "Testimony of Archæology," describing the Assyrian tablets of the Genesis, and he lays special stress on the occurrence of the deity *Il* in the Chaldean Pantheon, and shows its equivalence to the Hebrew *El-Eloah*, with its plural Elohim, and of the Arabic *Allah*. The author concludes that the legends of the creation having existed for a long time as oral traditions, were committed to writing before the union of the kingdoms, or before 2234 B. C., when Abraham, according to Biblical chronology, was not yet born. The date of Moses is about 1245 B. C., that of Menephthah, the Pharaoh of the Exodus. The Chaldean account is thus about a thousand years older than the composition of the Biblical legends. Interesting chapters follow on the myths of the old world which resemble those of Genesis.

The author then proceeds to the "testimony of facts." Here the descrepancies between the two accounts in Genesis and the discoveries of science are clearly pointed out. In his "Conclusion" and "Philosophy," the last two chapters of the book, the author contends that the literal teaching of the book of Genesis is hurtful to the minds of children, and an impediment to the general progress of mankind. Unessential as much of the scientific criticism, directed against the ethical portions of Scripture, is seen to be, such criticism must be appropriate when directed against a portion which deals almost exclusively with statements of facts. A classification of the treatment of religion by the Indo-European and Semitic races is attempted by the author, in which he shows that the leaning of the Indo-European religions is toward the intellectual side of the mind in its treatment of external objects. On the other hand, the leaning of the Semitic religions is toward the emotional side in its treatment of human conduct and family relations. The Gods of the two accounts in Genesis, expressed by nouns plural in form, mark a reminiscence of a preceding plurality of deities, and are plainly not consistent with monotheism. There has been, on the one hand, a growth in the direction of a recognition of a universal God, who at one time was tribal and national; and, on the other hand, there has been a progress in the direction of a recognition of one God, the final cause of nature, who has absorbed the minor deities into himself.

With regard to the two accounts in Genesis, the author concludes that we have to do with an original myth which had undergone many changes before it was cast into the two shapes in which we find it in the Hebrew Bible. Since that time, and when the latter could no longer change, many differing conceptions of the origin of things have found their orthodoxy in a play upon the meaning of the words and a distortion of their true intent. A lax wording, a shorter and more general statement, a monotheistic conception, give an elasticity to the story of Genesis, and a certain adaptiveness to later discoveries; but, in its treatment of the heavens and heavenly bodies in the little bit of the earth on which its miracles are performed, it is still akin to the notions of the Homeric ages with regard to the universe.

The book is characterized by directness of argument, and the best material has been diligently used. There can be no reasonable objection to its temper and tone, and, we think, its thorough fairness. Written with the object of giving a good foundation to those who have been led to reject the inspiration of Genesis, there is nothing in it which ought to be offensive to those who still accept that inspiration; rather is there abundant material for a careful resurvey of their position in the face of the new facts. The archæologist and philologist will find many new points in the book, which is noteworthy for its additions to science as well as for its distinctive literary merits.

The Physical History of the Triassic Formation of New Jersey and the Connecticut Valley. By Israel C. Russell. 1878.

The Triassic of New Jersey and of the Connecticut Valley are supposed by the author to be parts of one formation, which was continuous over the intervening area. The deposit, he thinks, could not have been less than 25,000 feet thick, all or nearly all of which has been removed by denudation, excepting the beds which remain in the Connecticut Valley and New Jersey. Professor Dana, commenting on this subject in the April number of the "American Journal of Science and Arts," says, "That a thickness of 25,000 feet of water made sandstone over an area of metamorphic rock a hundred miles wide, as in the present instance, implies a subsidence of the region of 25,000 feet during its formation." There must also have been an elevation of not only 25,000 feet, but enough more to give a pitch of the slopes of about 15° as now shown. This would put the western side of the Connecticut Valley 20,000 feet above the eastern side, and the site of New York City some 15,000 to 20,000 feet above its present level, with 25,000 feet of sandstone over it.

Erasmus Darwin. By Ernst Krause. Translated from the German by W. S. Dallas, with a Preliminary Notice by Charles Darwin. Portrait and Woodcuts. Pp. 216. Price, $1.25.

This interesting little volume will be welcomed by many readers, as it gives a fresh and compendious account of a man of genius whose name was celebrated in the last century, and is now brought into new prominence by the world-wide eminence of his grandson. Dr. Erasmus Darwin, who was born in 1731, and died in 1802, made a considerable impression upon his age as a poet and naturalist. He took a view of organic nature very similar to that developed in our own time by Mr. Charles Darwin, although his speculations were crude from the imperfection of knowledge, and were, of course, regarded as in the last degree wild and baseless. His poetry, although in some respects meritorious, was not of the highest order, and was but little read after he had passed away; and, as his biological doctrines were regarded as futile and worthless, there was little to keep his memory alive in the present century. But attention to what he did in science has been recently revived, and the more critical study of his works now shows that his claims and character have been greatly depreciated. The present volume has first done justice to his fame.

Mr. Charles Darwin, in his "Origin of Species," made a short note concerning his grandfather's biological opinions, and this struck the attention of Dr. Krause, a German *savant*, who entered upon a careful study of the writings of the elder Darwin, and published a biographical and critical essay upon the subject in the "Kosmos." In this essay Dr. Krause says: "This man, equally eminent as philanthropist, physician, naturalist, philosopher, and poet, is far less known and valued by posterity than he deserves, in comparison with other persons who occupy a similar rank. It is true that what is perhaps the most important of his many-sided endowments, namely, his broad views of the philosophy of nature, was not intelligible to his contemporaries; it is only now, after the lapse of a hundred years, that by the labors of one of his descendants we are in a position to estimate at its true value the wonderful perceptivity, amounting almost to divination, that he displayed in the domain of biology. For in him we find the same indefatigable spirit of research, and almost the same biological tendency, as in his grandson; and we might, not without justice, assert that the latter has succeeded to an intellectual inheritance, and carried out a programme, sketched forth and left behind by his grandfather."

Mr. Charles Darwin procured a translation of Dr. Krause's article, and, being in possession of much information that he had gathered in relation to his eminent ancestor, he has written a preliminary sketch which occupies 127 pages of the volume before us.

It gives an excellent account of its subject, supplementing Dr. Krause's paper, so that the readers of the book will be able to form not only a proper estimate of the man, but the condition of science in his time. A life of Erasmus Darwin, published in 1804, was written by a Miss Seward, but it seems to have contained certain gross misrepresentations of his character, which it is one of the objects of the present sketch to dispel. The authoress of the biography was long an inmate of Dr. Darwin's family, and when his first wife died would have been glad to take her place. But the Doctor chose another lady, and Miss Seward paid them both off in her biographical book. She subsequently retracted her objectionable statements, but the erroneous impressions, created by her book, were widely disseminated.

Mr. Darwin writes unreservedly but judicially of his grandfather's traits, and remarks that perhaps there is no safer test of a man's real character than that of his long-continued friendship with good and able men. Darwin's intimate and almost lifelong friends were such men as Josiah Wedgwood, Keir the chemist, Day, the author of "Sandford and Merton," Bolton and Watt the engineers, and Mr. Edgeworth. A fine likeness of Dr. Darwin accompanies the volume, together with engravings of his birthplace, Elston Hall, and the Breadsall Priory, near Derby, where he lived for many years, and in which he died.

Eighth, Ninth, and Tenth Annual Reports of the Geological Survey of Indiana, for the Years 1876, 1877, 1878. By E. T. Cox, State Geologist, assisted by Professor John Collett and Dr. G. M. Levette. Indianapolis, 1879.

These reports make a volume of 541 pages, and are illustrated by numerous diagrams and maps. The detailed reports are of three counties—Wayne, Crawford, and Harrison. These, as well as special reports on clays, cements, building-stone, etc., are well written, and show thorough work. A general review of the geology of the State by Professor Cox presents his conclusions on several points of interest. Of the glacial epoch, he says: "I see no evidence of a subsidence of land to terminate the glacial period, which continued until brought to a close by its own erosive force, aided by atmospheric and meteorological influences. . . . Its force was expended in eroding, cutting down, and removing mineral matter from a higher to a lower level." He does not believe it is possible for glaciers to make erosions to so great depths "as the beds of some of the great Northern lakes." The volume contains an excellent paper on archæology, a table of altitudes, catalogues of fossils and of recent flora, and, what is of especial value, "A Catalogue and Check-list of the Trees and Woody Shrubs of America north of Mexico." This was prepared by John W. Byrkit, Esq., of Indianapolis. The volume has a very full index.

Modern Meteorology. A Series of Six Lectures delivered under the Auspices of the London Meteorological Society in 1878. Illustrated. New York: D. Van Nostrand. 1879. Price, $1.50.

These lectures make a volume of 186 pages, and are a useful contribution to the science of meteorology. The subjects are treated in a somewhat elementary manner, but in the light of the latest researches. The first, and perhaps the most important lecture of the series, is by Robert James Mann, M. D., F. R. C. S., etc., on "The Physical Properties of the Atmosphere," and is a model of lucid scientific statement. Others are on "Air Temperature, its Distribution and Range"; "The Barometer and its Uses, Wind and Storms"; "Clouds and Weather Signs"; "Rain, Snow, Hail, and Atmospheric Electricity"; and "The Nature, Methods, and General Objects of Meteorology." This last, by Robert H. Scott, F. R. S., Secretary to the Meteorological Council, is worth careful perusal by both scientists and the general reader.

The Great Fur Land, or Sketches of Life in the Hudson's Bay Territory. By H. M. Robinson. With numerous Illustrations. New York: G. P. Putnam's Sons. 1879. Price, $1.75.

The fact that much of the contents of this volume first appeared in "Appletons' Journal" and "Harper's" and other magazines, does not detract from its value. It is a picturesque and thoroughly readable account of life and scenery in the region occupied by the Hudson's Bay Company, and some of the pictures are uncommonly well drawn. The descriptions of the great fall hunt, of the manners and habits of the hunters, of traveling over the vast prairies during winter, of the mirage and other atmospheric phenomena, are excellent, and, although there is no attempt at scientific statement, they give one a good idea of the extent of an important industry, and of the kind of life adopted by those who pursue it.

THE BEREA SANDSTONE OF OHIO. By Professor EDWARD ORTON, of the Ohio State University. Pp. 9.

THIS is a review of the facts brought out by the Geological Survey of Ohio, concerning one of the most important geological formations of the State, the Berea sandstone. It extends in a continuous line of outcrop more than four hundred miles, through twenty-one counties, the stone of best quality, however, being found at Berea, in Cuyahoga County, whence its name. Building-stones and grindstones, to the amount of several million dollars, are annually obtained from this enormous deposit. The facts presented by Professor Orton are not only interesting from an economic point of view, but are of special value to the geologist.

PUBLICATIONS RECEIVED.

Report on Magnetic Determinations in Missouri. By Francis E. Nipher. Pp. 24, with Map.

Report of the Commissioners of Fisheries of California for 1878 and 1879. Pp. 61.

Indian Corn. By E Lewis Sturtevant, M D., South Framingham, Massachusetts. 1880. Pp. 31.

"The American Entomologist." Edited by Charles V. Riley and A. S. Fuller. Monthly. Vol. I. New Series. No. 1. January, 1880. New York: Max Jægerhuber, Publisher, 323 Pearl Street. Pp 24. $2 per annum.

Responsibility restricted by Insane Delusion. By T. L. Wright. Bellefontaine, Ohio. Pp. 16.

How to learn Short-Hand. Baker. New York: S. R. Wells & Co. 1880. Pp. 43.

Notes of Students' Work in the Chemical Laboratory of the University of Virginia. No. VIII. Communicated by J. W. Mallet. London, 1879. Pp. 14.

Relations of Railroads to the Public. By F. B. Thurber, of New York City. Pp. 18.

The Origin of Force. By Stephen C. Hutchins. Albany. 1879. Pp. 8.

Some Additional Notes on Ozone. Pp. 22. Contributions from the Laboratory of the Stevens Institute of Technology. By Albert R. Leeds, Ph. D. Pp. 13. Reprints from "Journal of American Chemical Society."

Solar Parallax from the Velocity of Light. By D. P. Todd, M. A. Pp. 6.

Thirty-fourth Annual Report of the Director of the Astronomical Observatory of Harvard College. By Edward C. Pickering. Cambridge. 1880. Pp. 14.

A Lecture on Man. By Charles S. Bryant, A. M. St. Paul, Minnesota. Pp. 53. 35 cents.

"The American Monthly Microscopical Journal." Edited and Published by Romyn Hitchcock. Vol. I., No. 1. January, 1880. Pp. 20. 51 Maiden Lane, New York. $1 a year; single numbers, 15 cents.

Civilization: Is its Course natural or supernatural? Philadelphia: Charles H. Marat. 1879. Pp. 140.

Fourth Annual Report of the Board of Managers of the Wisconsin Industrial School for Girls. Milwaukee, 1880. Pp. 52.

Remedy for Existing Evils, Social and Political. By Judge S. D. J. Moore. Nashville. 1879. Pp. 116.

Notes on New England Isopoda. By Oscar Harger. Pp. 9.

New Characters of Mosasauroid Reptiles. By Professor O. C. Marsh. Pp. 5, with Plate.

On a New Theory of the Retaining Wall. By A. J. Du Bois, Ph. D. Reprint from "Journal of the Franklin Institute." Pp. 27.

The State of Prisons and of Child-saving Institutions in the Civilized World. By E. C. Wines, D. D., LL. D. Cambridge, 1880. Pp. 708.

Etymological Dictionary of the English Language. By Rev. Walter W. Skeat. Part II., Dor–Lit. $2.50 per part.

The Native Flowers and Ferns of the United States. By Thomas Meehan. Second Series. Parts 9, 10, 11, 12, Vol. I.; Parts 13, 14, 15, and 16, Vol. II. Illustrated.

On the Determination of Verdet's Constant in Absolute Units, and on the Specific Inductive Capacities of Certain Dielectrics. By J. E. H. Gordon, B. A. Cantab.

Brain-Work and Overwork. By Dr. H. C. Wood. Philadelphia: Presley W. Blakiston. 1880. Pp. 126. 50 cents.

Linkages for Different Forms and Uses of Articulated Links, by J. D. C. DeRoos; Theory of Solid and Braced Elastic Arches, by William Cain. C. E.; On the Motion of a Solid in a Fluid, by Thomas Craig, Ph.D. New York: Van Nostrand's Science Series. 1879. 50 cents each.

The Child's Catechism of Common Things. By John D. Champlin, Jr. New York: Henry Holt & Co. 1879. Pp. 289. 60 cents.

Outlines of the Art of Expression. By J. H. Gilmore, A. M. Boston: Ginn Bros. 1876. Pp. 117.

Blowpipe Analysis. By J. Landauer. London: Macmillan & Co. 1879. Pp. 161. $1.50.

Part V., Report of United States Commission of Fish and Fisheries for 1877. Propagation of Food Fishes. Washington: 1879. Pp. 981.

Problems of Life and Mind. By George H. Lewes. Third Series. Boston: Houghton, Osgood & Co. 1880. Pp. 500. $3.

The Economics of Industry. By Alfred Marshall and Mary Paley Marshall. London: Macmillan & Co. 1879. Pp. 231. $1.

Studies on Fermentation. By L Pasteur. London: Macmillan & Co. 1879. Pp. 418. $6.50.

Popular Romances of the Middle Ages. By Sir George W. Cox and Eustace Hinton Jones. New York: Henry Holt & Co. 1880. Pp. 514. $2.25.

Pharmacographia: a History of the Principal Drugs of Vegetable Origin met with in Great Britain and British India. By Friedrich A.

Flückiger and Daniel Hanbury, F. R. S. London: Macmillan & Co. 1879. Pp. 803. $5.

A Handbook of Double Stars. By Edward Crossley, Joseph Gledhill, and James M. Wilson. London: Macmillan & Co. 1879. Pp. 464. $6.

The Microscope in Medicine. By Lionel S. Beale. Philadelphia: Lindsay & Blakiston. 1878. Pp. 528. $7.50.

A Treatise on Vocal Physiology and Hygiene. By Gordon Holmes, F. R. C. P. Philadelphia: Presley W. Blakiston. 1880. Pp. 266. $2.

The Refutation of Darwinism and the Converse Theory of Development. By T. Warren O'Neill. Philadelphia: Lippincott & Co. 1880. Pp. 544. $2.50.

Sunshine and Storm in the East. By Mrs. Brassey. With upward of a Hundred Illustrations. New York: Henry Holt & Co. 1880. Pp. 448. $3.50.

England: her People, Polity, and Pursuits. By T. H. Escott. New York: Henry Holt & Co. 1880. Pp. 625. $4.

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

A Manual of the Antiquity of Man. By J. D. Maclean. Cincinnati: Robert Clark & Co. 1879. Pp. 159. $1.

How to educate the Feelings or Affections. By Charles Bray. Edited by Nelson Sizer. New York: S. R. Wells & Co. 1880. $1.50.

POPULAR MISCELLANY.

Action of Organic Acids on Minerals.—At a recent meeting of the New York Academy of Sciences, Professor H. Carrington Bolton, of Trinity College, Hartford, communicated the results of a continuation of his researches on the behavior of minerals with organic acids. In a previous paper (read in 1877) he gave the reactions of ninety-five minerals with citric acid; in the present paper he extended the investigation to two hundred species. Dr. Bolton stated that citric acid has a power of decomposing all classes of minerals little less than that possessed by hydrochloric acid, and that this very difference in degree gives the organic acid an advantage over the mineral acid in the determination of species. Besides treating the minerals with a saturated solution of citric acid, he examined the action of the same solution, to which solid sodium nitrate is added. This mixture proves to be a very powerful solvent, dissolving bismuth, antimony, arsenic, copper, lead, tin, mercury, and silver, and nearly all the natural sulphides. The addition of solid potassium iodide to the solution of citric acid also greatly increases its decomposing power. Applying these reagents to minerals, Dr. Bolton obtained the following results: 1. Complete solution of carbonates, with liberation of carbonic-acid gas. 2. More or less complete decomposition of oxides, phosphates, etc. 3. More or less complete decomposition of sulphides, with liberation of sulphuretted hydrogen. 4. Decomposition of sulphides, with oxidation of the sulphur. 5. Decomposition of silicates, with separation of slimy or gelatinous silica. 6. Decomposition of certain species, with formation of characteristic precipitates. 7. Wholly negative action. The exact behavior of each of the two hundred minerals was given in a printed table, copies of which the speaker distributed to the audience. The application of this investigation is twofold: 1. The utility of the methods in field-work, owing to the portability of the reagents in a dry state; and, 2. The relation of these reactions to the geological work of the organic acids of the soil. The latter point is of much importance, and merits further researches.

How Snakes shed their Skins.—Under the title "About Snakes" in this department of our last number, we gave Dr. H. F. Hutchinson's mode of accounting for the way snakes get out of their old skins. Professor Samuel Lockwood, of Freehold, New Jersey, has witnessed the process, and, from a description of it given in his own inimitable style in a late number of "Nature," we gather the following interesting facts, which, as will be seen, do not support the hypothesis of Dr. Hutchinson: A female snake had already begun to cast her skin when Professor Lockwood made his first observation, but the process was going on very slowly. The skin was slightly torn at the snout, and the head and a little of the neck were denuded. As it separated from the neck it had a sort of "back-creeping aspect"; there was no rubbing against exterior objects, and indeed it looked as if the change going on might be the work of an invisible power. Closer observation showed that there was a systematic alternate swelling of the body at the neck of the skin, thus stretching it, and making a shoulder in front of this neck, each swelling pushing the loosened skin a little backward. As soon as the process reached the larger ribs it went on more rapidly, and in the following way:

"Exactly at the place where the skin seems to be moving backward, a pair of ribs expands. This action enlarges or puffs out the body, and by stretching loosens the skin at that place. In this movement both ribs in the pair act at the same time, just as the two blades of the scissors open together. Now comes a second movement of this pair of ribs, in which action the two ribs alternate with each other. One of them—say the one on the right side—is pushed forward and made to slip out of and in front of the constriction made by the swelling, when it immediately works backward, that is, against the neck of the double receding skin. Now the left rib makes a like advance, and in a similar manner presses backward." Thus, for every backward movement of the inverting skin, there are three rhythmic movements: First, the expansion of one pair of ribs; second, the swelling of the body at that spot; and, third, the pushing back of the skin by the alternate action of each rib. "The cast-off skin is presented inside out, so that every scale is now seen on its under or concave side, and this is also true of the eye-scales. To all this there is one exception; the last scale of the tail is a hollow pyramidal or four-sided spike. . . . When the shedding has reached this scale a sharp shake of the extremity is sufficient, and the unverted spike is left inside of its everted skin." The entire process witnessed by Professor Lockwood took only half an hour, but he says that if a snake is in poor health the casting of its old clothes takes longer and is a much more difficult matter.

A New Food-Fish.—Among the many remarkable results given in the last report of the United States Fish Commission is the discovery of a very important food-fish, entirely unknown to our fishermen. It is a large flounder, the *Glyptocephalus cynoglossus*, and is known in Europe as the pole or craig. But in Europe it is far from being plentiful, and is highly esteemed as having some of the best qualities of the turbot, especially the presence of that delicious gelatinous fat along the fins. Much of the work of the Commission has consisted of dredging in water of various depths. While trawling with a beam at distances from five to ten miles from the shore, the fish was discovered, and in great quantities; so great, indeed, that a fifteen to twenty minutes' drag would sometimes furnish as many as five hundred pounds of the fish. The reason that this fish has not been known hitherto is due to the fact that the beam-trawl, the only apparatus by which it can be taken, is not used by our American fishermen, as it is by those of Europe. The mouth of this large flounder is so small that a hook small enough to be swallowed would not sustain the weight of the fish. There is every reason to expect that this fish will soon take its place in our markets. The Commission have also brought to light *new species* of food-fishes, i. e., of fishes supposed hitherto as only living in the colder waters of Greenland and Scandinavia. These, too, American enterprise will yet bring to our markets; but, to do so, fishing must be carried on two or it may be three hundred miles from the coast.

Improved Method of diving and staying under Water.—The apparatus now in use for supplying air to divers engaged in submarine operations is both cumbrous and unsafe, the air-tube limiting the movements of the diver, and, by its liability to become entangled and crushed, causing a risk that the supply of air for respiration may be cut off altogether. A new method, in which these drawbacks are escaped by dispensing entirely with the air-tube and pumps, has been invented by a Mr. Fleuss in England, and lately exhibited at the Royal Polytechnic Institute in London. Dr. B. W. Richardson was given an opportunity to closely watch its operation, and from his description in "Nature" we glean the following account of the experiments: The peculiarity of the method consists in the diver's taking a full supply of air-food down with him, which dispenses with pumping, no help being needed except a signal-man and cord. Mr. Fleuss is both inventor and diver. He descends into the water in an ordinary diver's dress. It consists of helmet, breastplate, and common water-tight armings and leggings. On his shoulders he carries a weight of ninety-six pounds, and on his boots twenty pounds. A light cord is attached to the helmet for signaling to the person above. Before the mask is closed and the helmet adjusted, an "ori-nasal mouthpiece," with a breathing-tube of an inch bore proceeding downward, is firmly tied over the mouth and nose. Dr. Richardson carefully observed two experiments, one of twenty minutes' length, and another of an hour; and was assured by the diver that when under water he breathed as freely and easily as in the air. This was confirmed by his appearance and condition at the end of the longest experiment. He moved about on the floor of the tank, picked up coins, and could lie down and get up without difficulty. The exact mode by which breathing is effected Mr. Fleuss declares to be extremely simple, though it still remains a secret, but it is wholly carried on within the apparatus, not even the expired air becoming apparent in the water. The facts demonstrate that, without assistance from above, a man who has had no previous experience of diving or remaining under water can take down with him sufficient oxygen to live there easily for an hour; and but for the cold the diver asserted that he could have remained another hour and a quarter, and that he could easily arrange to remain four hours. Depth he said would make no difference as to breathing within the apparatus. Dr. Richardson is enthusiastic over the practical possibilities of the discovery. If a man can thus take his stock of breathing material with him, and live for hours without external access of air, he may extend the field of his industries and investigations into the deep sea, or the most rarefied atmospheres, into mines filled with choke-damp, or amid the suffocating smoke of conflagrations, without fear of consequences.

Suicide of the Scorpion.—The following facts, as stated by Mr. Allen Thomson in "Nature," throw some light on the mooted question of the self-destruction of scorpions. He states that while residing at Lucca, in Italy, he was greatly annoyed by the intrusion into the house of small black scorpions, which secreted themselves in bed-clothing and articles of dress. Having been informed by the natives that this animal would destroy itself if exposed to a sudden light, attempts were made to dispose of the pest in the manner suggested. When one was caught it was accordingly confined under an inverted glass until evening, when the light of a candle was brought near it. At this, the scorpion showed great excitement, rushing round the glass with reckless speed. This state lasted for a minute or two, when the animal suddenly became quiet, and turning his tail over its back brought the recurved sting down upon the middle of its head. Soon it became motionless, and in fact dead.

Electricity and Vegetation. — Several months ago M. Grandeau and M. Leclerc described to the Paris Academy experiments on the influence of electricity on vegetation. From these it appeared that flowering and fructification are retarded whenever plants are excluded from this agent. Recently M. Naudin has been examining the subject, repeating the experiments of Grandeau and Leclerc under different circumstances, and with widely different results. He regards the question as a complex one, and far from being yet settled. The influence of electricity on plants is probably modified by the species, by climate, season, temperature, dry or wet weather, degree of light; possibly, also, by the geological and mineralogical structure of the ground. Until we are better acquainted with these obscure conditions of the problem, any conclusion applied to the whole of the vegetable kingdom is premature.

Transmissibility of Human Rabies. — Whether hydrophobia can be transmitted from man to man, or from man to the lower animals, has long been a disputed question, with little scientific evidence on either side; some recent observations, however, by M. Raynaud, in the Lariboisière Hospital, in Paris, would seem sufficiently conclusive to put an end to all uncertainty on the subject. A man was brought to the hospital suffering from rabies, having been bitten by a dog on the lip forty days before. The wound was cauterized two hours after it was made, and no serious apprehensions were felt about the result until a few days before he entered the hospital, when the usual symptoms of hydrophobia appeared. The day before his death, in a quiet interval, he yielded with the best grace to experiments in inoculation which were made with his blood and his saliva. The result of inoculating a rabbit with the blood was negative (as in the great majority of previous cases of inoculation with blood of animals under rabies). But with the saliva it was different. A rabbit inoculated in the ear and abdomen on the 11th of October began to show symptoms of rabies on the 15th, being much excited and damaging the walls of its cage, while it uttered loud cries and slavered at the mouth. Then it fell into collapse and died the following night. The rabbit's body was dissected thirty-six hours after death, and further experiment was made by taking fragments of the right and left submaxillary glands and introducing them under the skin of two other rabbits respectively. These two rapidly succumbed, one on the fifth, the other on the sixth day (becoming visibly ill on the third); neither passed through a furious stage, however, and the predominant feature was paralysis. The important practical result is, that human saliva, such as caused rabies in the rabbit, is necessarily virulent, and would probably have corresponding effects on man; so that it should be dealt with cautiously, and that not only during the life of the person furnishing it, but in *post-mortem* examinations.

The Agency of Plants in Earth-Building.—The important question of the part taken by plants in earth-building is discussed by Professor Ernst Hallier, of Jena, in a popular essay on "Plants and Man in their Interrelations." The contributions made by the vegetable world to the formation of the crust of the earth are most obviously shown in the beds of peat and coal, the remains of former immense forests and swamps. These formations, remarkable and important as they are, Professor Hallier observes, are far exceeded by the less apparent changes which are effected by the agency of plants. The deposits of fresh-water limestones are largely the results of plant-action. Nearly all the streams in calcareous regions bring down carbonate of lime in solution as a bicarbonate. Their waters being charged with carbonic acid or having absorbed it from the air, are by its aid enabled to act upon the otherwise insoluble carbonate of lime, and to take up a quantity of it proportioned to the amount of carbonic acid they contain. This dissolved lime is in its turn converted by the plants which grow in and under the water into stone. All the carbon that is needed for the organic world, animals as well as plants, is obtained through the action of plants in extracting carbonic acid from the air. Plants and those parts of plants which are under water do not stand in direct relations with atmospheric air, but are dependent on the carbonic acid which is held in the water, and, when this is exhausted, on the dissolved bicarbonate of lime. A part of the carbonic acid is taken up from this substance by the chlorophyl-cells, while the other part remains fixed in the lime in the form of simple carbonate of lime. Since the latter is insoluble in water, it is deposited just where it happens to be, which in this case is on the surface of the plant, and this becomes covered with a coating of limestone. Fresh supplies of water bring down new stores of carbonic acid and the dissolved bicarbonate of lime, and the plants continue their work of converting the latter into the insoluble carbonate. Thus the work goes on unceasingly, and crust on crust of limestone is deposited on millions of small plants. The plants themselves die, wholly incased in stone, but new ones succeed them, and the layers of petrified plants bear in continuous succession a green coating of growing plants. Strata are added to strata, and the limestones grow enormously through the quiet activity of the charæ, mosses, reeds, grasses, and other plants in the water. Fresh-water limestones are thus still in process of formation in all limestone regions. The minor valleys of the Thuringian Valley contain large bodies of soft, fresh-water limestones, in which the forms of the plants to whose action they are due may be plainly recognized, partly in incrustations, partly in impressions, mixed with fresh-water shells and with remains of the trees which once grew on the shore. The material, though soft, has been used in the manufacture of a building-stone out of which cities like Jena and many towns have been built. Rock-building of this kind has been going on ever since there was a growth of plants on the earth, and has during that time played a considerable part in forming the crust of the earth. Other far smaller plants are occupied in building up rocks, in comparison with the work of which, the labor of the plants we have considered may be called insignificant. The diatoms, which live in fresh and salt waters, are the smallest of all organisms. They were once thought to be animals, but are now regarded as plants, and are one-celled structures which have the property of sucking up large quantities of carbonic acid from the water and storing it in their cell-walls. They increase by repeated divisions and subdivisions of their cells, and build up rocks by their simple presence. They multiply with such prodigious rapidity, and the number of their genera and species is so great, that under favorable conditions, as in the shallows and muddy flats of the seashores and in wet places in the interior, they contribute the substance of whole strata by leaving behind them when they die their silicated cell-walls, which become consolidated with the earthy materials into a harder or softer rock-formation. The magnitude of the operations of this kind that are going on in the present epoch is illustrated in the Lüneberg heath, where the diatomaceous formation is more than thirty feet thick. The city of Berlin is built upon a bed of clay of from six to one hundred feet thick, two thirds of the mass of which consist of diatoms. There is a puzzling feature in the life of these diatoms. They contain a coloring matter, *diatomin*, which is similar to chlorophyl in its properties and in having the power of abstracting carbonic acid from the air and water. It is hard to understand how this power can be exercised where the light does not penetrate. Yet a great mass of the diatom bed under Berlin is living and active, and streets and houses have been disturbed by its growth. The functions which the diatoms perform in the present history of the earth were also exercised by them during the earliest epochs of which we know, and probably in still earlier times.

Intelligence of a Pet Monkey.—A writer in "Chambers's Journal" vouches for the truth of the following story about a pet monkey, which, even if taken with many grains of allowance, exhibits a remarkable degree of intelligence that, in many respects, seems scarcely less than human: "Peter" belonged to an officer in the British Army, and was a large and powerful specimen of his class. He was a general favorite, his unusual sagacity and varied accomplishments forming a source of endless amusement, and, although somewhat mischievous, his gentleness of disposition and genuine love of fun readily secured forgiveness for occasional annoying pranks. Unfortunately, however, Peter had an enemy in the person of a diminutive and unpopular subaltern, to whom he appears, in some mysterious way, to have rendered himself particularly obnoxious. During a temporary absence of his master the monkey was intrusted to the care of a brother officer, who, being anxious that he should suffer no harm, chained him to a chest of drawers in his own room. This well-meant restraint did not coincide with Peter's desire for freedom, and, left to his own resources, he sought about for some means of diversion. Having first forced open the locks of all the drawers, he strewed their contents upon the floor, and seated himself in the midst, "monarch of all he surveyed." Next, discovering an inkstand within reach, he bedaubed with its contents every article belonging to his hospitable entertainer. When his host returned, Peter appeared totally unconscious of having been guilty of the slightest misdemeanor. He was not punished, but summarily dismissed from his comfortable quarters and allowed to wander freely about the barracks. All went well for a time, but, later in the course of one of his rambles, Peter unluckily encountered his enemy, and, springing upon the shoulder of the irate and alarmed subaltern in the presence of a large number of officers and men, he nearly succeeded in drawing the sword of his victim, who, according to report, was not at all likely to draw it himself. The ludicrous position of the latter, amid the loud laughter of the men, served only to increase the subaltern's hatred of the popular monkey. Shortly after this, Peter was fired at and seriously injured. Though it was impossible to prove who was guilty of this cowardly act, it was naturally attributed to the subaltern, who, it was well known, had never forgiven the indignity inflicted upon him in public. Peter's friends exerted themselves to save his life;

the slugs were extracted, and he was soon convalescent. At this juncture his master returned, and the joy of the monkey was unbounded. "He clung to him and fondly embraced him over and over again, repeatedly kissing or rather licking his face and hands, with every possible demonstration of the most devoted attachment." When the first paroxysm of delight was over, Peter clasped the arm of his friend to bespeak special attention, "pointed with his own forefinger to each of the wounds whence the slugs had been taken, trying at the same time, in the nearest approach to speech that he could accomplish, to tell the piteous story of his narrow escape from a violent death. . . . It is questionable if the most intellectual of human beings not gifted with the power of speech could have acted more pathetically, or indicated more vividly what had occurred to them during the absence of their natural protector and dearest friend."

Announcement of Astronomical Discoveries.—For the purpose of making astronomical discoveries known to the public, speedily and in a systematic manner, Lord Lindsay has devised a plan for international communication of such information, and sent circulars to the leading observatories, public and private, everywhere. He promises to distribute notices of discovery within twenty-four hours of the receipt of the telegram to those who favor him with their addresses. The following is the substance of his circular:

The Observatory, Dun Echt, Aberdeen,
November 1, 1879.

Sir: I am very anxious to form some system whereby information of astronomical interest may be rapidly and widely disseminated among English observers, and I would beg to ask for your assistance in carrying out my plan. In the event of your discovering a comet, new star, or other object of immediate interest, I would ask you to send me a telegram announcing the discovery, and giving such details as are usual. I have purposely omitted to mention minor planet discoveries, inasmuch as this branch is already admirably carried out by the Berlin Observatory. For convenience, the telegram should be in the form recommended by the Vienna Academy in the seventy-fifth volume of the "Astronomische Nachrichten," No. 1785, page 142, as follows: Comet (new star, etc.), discoverer, date, local mean time of observation (in hours and minutes), place of discovery, right ascension *in arc* (degrees and minutes), north polar distance (degrees and minutes), daily motion in R. A. and N. P. D. (minutes of arc), plus or minus, description, diameter of comet, etc. (in minutes of arc).

Thus a telegram would run:

Comet Winnecke, 5 April, 1445. Strasburg, 3315707508. Motion 0, minus 60.

This would read:

Comet discovered by Winnecke, 5th of April, 14 hours 45 minutes mean time, Strasburg, R. A., 331° 57′, N. P. D., 75° 8′. Daily motion, stationary, R. A., minus 60′ in polar distance.

Naughts should be put in where there are no significant figures, so as to make three figures for degrees and two for minutes (five in all), in R. A. and in N. P. D.; similarly, four in the local time.

Telegrams, etc., should be addressed *Observatory, Dun Echt, Aberdeen.*

(Signed) Lindsay,
President Royal Astronomical Society.

Arsenic in the Household and School.—When somebody is accused of having dosed a fellow mortal to death with arsenic, State authority and newspaper interest immediately vie with each other in their efforts for the protection of human life. Unfortunately, however, both are much less alive to other and far greater dangers arising from the reckless employment in the arts and manufactures, and the ignorant introduction into our households, of this same deadly poison. Its use in the preparation of pigments is very common, and the employment of these for coloring articles of attire and for the various styles of paperhangings is scarcely less so. Not only are those engaged in the manufacture of these coloring matters exposed to the deleterious influence of the poison, but far larger numbers ignorantly purchase and use the articles containing it, and in a way that makes its action but little less virulent than the direct administration of the pure drug. Instances of this are constantly recurring in medical practice. Socks colored with compounds containing arsenic have produced disease of the feet; boots lined with flannel colored with Scheele's green have caused the death of their wearers; bright maroon-colored flannel worn next the skin, paper collars, neckties, hat-linings, gloves, artificial flowers, and even ladies' dresses, have all been the cause of disease from the presence of this poison. Its use for coloring wall-papers, and especially the cheaper sorts, is almost universal; and, while the greens are probably the worst of the lot, they are by no means the only ones containing arsenical pigments. A recent number of the "Lancet" gives an account of an aggravated case of poisoning, due to a red paper on the walls of a sitting-room; and arsenic has also been found in white, gray, blue, mauve, and brown wall-papers in abundance. As an instance of the utter disregard of consequences shown by manufacturers in the use of these pigments, we may cite the statement published by Miss Osborne, of the Sydney Hospital, New South Wales, that large quantities of poisonous pigments are consumed in that colony in coloring sweetmeats for children. We give in another place in this number a letter from a chemist in Pittsburg, showing an equally flagrant case of carelessness in the manufacture and use of arsenical papers for the operations of the kindergarten. People who thus disregard the welfare of their fellows, scattering poison broadcast in a way that neither age nor condition can escape, are, we submit, entitled to some small share of attention from the press, and from the courts.

Artificial Diamonds.—The "todo" about the artificial production of the diamond has been set at rest by Professor Maskelyne, who, in reply to numerous letters of inquiry on the subject, sends to "Nature" the results of his examination of the Macteor specimens which came into his hands for the purpose. He tested these so-called diamonds—1. With reference to their hardness; 2. Their refracting power; and, 3. Their combustibility. The samples sent to him were "too light to possess appreciable weight, too small even to see, unless by very good eyesight or with a lens," yet were sufficiently large to serve his purpose. "A few grains of the dust—for such the substance must be termed—were placed between a plate of topaz—a cleavage-face with its fine, natural polish—and a polished surface of sapphire, and the two surfaces were carefully 'worked' over each other with a view to the production of lines of abrasion from the particles between them. There was no abrasion. Ultimately the particles became bruised into a powder, but without scratching even the topaz. They were not diamond. Secondly, some particles more crystalline in appearance than the rest were mounted on a glass microscope slide and examined in the microscope with polarized light." They each and all presented powerfully the property of doubly refracting light. Finally, two of these microscopic particles were exposed to the intense heat of a table blowpipe on a bit of platinum-foil. They did not burn. They were afterward placed in contact with two little particles of diamond-dust, exceeding them in size, and the experiment, on being repeated, "showed that the diamond particles glowed and disappeared, while the little particles from Glasgow were as obstinate and as unacted on as before." When subjected to a stream of oxygen gas the result was the same. Hence, Professor Maskelyne concludes that the substance supposed to be artificially formed diamond *is not diamond* and *is not carbon.* Further experiments led him to the conclusion that it consisted of some crystallized silicate, or possibly of more than one such.

The fate of the Glasgow diamonds has induced Professor W. Mattieu Williams to send to "Nature" an account of his experience in diamond-making, for the benefit of those who may have an attack of the diamond mania. He states that for the popular class-room experiment of burning phosphorus in oxygen he used a cup of chalk, deeper and with a smaller rim than the brass cups usually made for this purpose — the object of this being to check too rapid outburst of combustion. He observed that a cup, several times used for this purpose, became coated on the inside with a hard, glassy enamel, which he supposed to be phosphate of lime. To test this, the cup was thrown into hydrochloric acid and dissolved, but at the bottom there remained a residue of insoluble crystalline particles. "Could it be possible that the carbonic acid, driven off by heating the chalk, had, in reaching the heated phosphorus, become dissociated, its oxygen combining with the phosphorus, and its carbon thrown down as veritable diamond?" These crystalline particles when tested were found to scratch a glass pestle and mortar in which they were rubbed, but were too small for further examination. To obtain a better supply, phosphorus was dissolved in bisulphide of carbon, and this solution mixed with pounded chalk constituted a paste which was put into a porcelain crucible, and the mass fired by heating it over a Bunsen burner. "It blazed magnificently, throwing out eruptive jets of flame. Here, in the absence of surrounding oxygen, the carbonic acid had every opportunify of becoming dissociated or reduced by the heated phosphorus." The residue, treated with hydrochloric acid, yielded a quantity of crystalline grains. These, when tested, left scratches on the glass mortar and pestle, and even seemed to leave slight marks upon an agate pestle and mortar. Examined, however, under a microscope, they resembled pebbles more nearly than crystals, and this fact led to the theory that they were "miniature chalk-flints formed by the fusion and aggregation of the silicious cuticles of fossil diatoms." This was tested by precipitating pure carbonate of lime, soaking it with the phosphorus solution, and, after firing it, treating it with hydrochloric acid, when *all trace* of dissociated carbonic acid disappeared, and neither diamonds nor other crystalline residue remained.

A New Preservative Process. — Herr Wickerscheimer, preparator in the Zoötomical Museum of Berlin, has invented a process for preserving plants and the bodies of animals, which has appeared to be of such value that the Prussian Government has procured the patent, and given it to the public. The inventor describes the process in his specifications as follows: "I prepare a fluid with which I impregnate the object to be preserved in different ways, according to its nature or the purpose I have in view, or the manner in which I preserve it. The bodies of men and animals preserved by this process retain perfectly their form, color, and suppleness, so that we may take sections from them years afterward for the purposes of science or of criminal justice. Under its operation, corruption and the insalubrious odors produced thereby cease. The muscular tissue presents on cutting it a condition like that of a fresh body. Finished preparations of selected parts, as the ligaments, lungs, intestines, etc., preserve their softness and flexibility, and the hollow parts may be even blown out. The parts of bugs, crustaceans, and worms, remain movable without exception. The colors may be made to remain perfect if it is desired, in animal as well as in vegetable bodies. The preserving fluid is prepared as follows: In 3,000 grammes (46,500 grains) of boiling water dissolve 100 grammes (1,550 grains) of alum, 25 grammes (387 grains) of common salt, 12 grammes (186 grains of saltpeter, 60 grammes (930 grains) of potash, and 10 grammes (155 grains) of arsenious acid. To ten quarts of the neutral colorless and odorless fluid add four quarts of glycerine and one quart of metylalcohol. The process of preservation, which is applicable to the dead bodies of men, dead animals, and vegetables, as well as to single parts of the same, consists, to speak generally, in soaking them and impregnating them with this mixture. If the preparations are to be preserved dry, they are kept in the fluid for from six to twelve days, according to their size, then taken out and dried in the air. The ligaments of skeletons, the muscles, crustaceans, bugs, etc., will then remain soft and pliable, so that all the natural movements can be produced on them at any time. Hollow organs, as the lungs, intestines, etc., are filled with the fluid before being put into it. After taking them out and pouring out the fluid from the inside, they are dried, and should then be blown out. If it is desired to preserve smaller animals, like lizards and frogs, and vegetables, with their colors unchanged, they should not be dried, but should be kept in the fluid. If bodies of men or beasts are to lie for a considerable time before being used for scientific purposes, it is enough to infect them with the preservative fluid. For this purpose, I apply, according to the size of the object, one and a half litre (about three pints) of the fluid for a child of two years, five litres (or quarts) for a grown person. The muscles will appear then, even after the lapse of years, fresh when cut. If the infected bodies are kept in the air, they will lose their fresh appearance, and the epidermis will become somewhat brown; but that may be avoided if the body is rubbed on the outside with the fluid, and is then kept shut up in an air-tight case. The last method is recommended in the case of corpses which are to be kept for some time before they are buried; instead of having the usual stiff look, the features and color will seem fresh and unchanged, and the bodies will not have a trace of odor. For embalming, I infect the corpse first, then put it into the fluid, and, after keeping it there for a few days, rub it and dry it, wrap it up in a cloth moistened with the preserving fluid, and keep it in an air-tight case. The treatment in different cases is governed by circumstances, but the composition of the preserving fluid is always the same."

Applications for Phylloxera.—M. Mouillefert, of the École Nationale d'Agriculture of Grignon, reported to the Academy of Sciences, Paris, November 10th, the results which had been obtained from the treatment of vines affected by the phylloxera with sulpho-carbonate of potassa. The efficacy of the salt appeared to be certain when it was applied with water according to the rules approved by the commission of the Academy. Vines that were very much weakened had been regenerated after such treatment, became free from spots, and bore fruit as they had done before they were attacked. The importance of water as the vehicle with which the remedy should be applied was strongly insisted upon. The sulpho-carbonate may be applied in all weathers and in all seasons, even in the cold months, without any danger to the vines; up to a certain dose (eighteen to twenty-five ounces to the square yard), the remedial effects are in nearly a direct proportion to the amount of the salt applied. At a subsequent meeting of the same body, December 1st, M. Frémy disputed the value of the sulphuret of carbon as a remedy for the phylloxera, and asked several questions of M. Thénard, who has recommended the application of that substance, as follows: 1. We know that sulphuret of carbon kills the phylloxera, but it also kills the vines; can we find a certain way of securing the former result while we avoid the latter? 2. Can sulphuret of carbon be easily and practically applied without affecting the health of the vine-dressers? 3. It is alleged that, by sacrificing one third of the vines, we can save the other two thirds; is this true? 4. Has the invasion of the phylloxera been arrested anywhere by the employment of sulphuret of carbon? Even if we are pointed to an apparent instance of the fact, we shall have to accept it with reserve; for cases are known in which vines which have not been treated still remain healthy in the midst of contaminated vineyards. M. Thénard failed to give a precise reply to the questions, which indicate very clearly the qualities that are required in a safe and efficacious remedy for the disease.

Parkes on Tobacco-Smoking.—We give below a very interesting and instructive letter written by the late Dr. Parkes, a short time before his death, in reply to a request for his views on the subject of tobacco-smoking, and recently published in the "Lancet":

My dear Dr. Pratt: I think my state of mind as regards tobacco is very much what yours seems to be. I have honestly tried to collect evidence from *moderate* smokers, both medical men and others, and, when tolerance has been established, I have never been able to make out any symptoms which implied injury. In the case of many medical men whom I have asked to study their own condition, the answer has always been the same—viz., they could see no harm or disturbance of any function. Even in some cases of enormous smokers—i. e., men who rarely were without a pipe or cigar—I could learn of no injury. On the other hand, I have seen, like all of us, men complaining of dyspepsia, nervousness, palpitation, etc., and who were much better for leaving off smoking; in fact, in these cases there could be no doubt of an injurious effect. In boys of fourteen or fifteen who begin to smoke, I think I have observed that tolerance is slowly attained, that appetite is less, and I presume digestion and nutrition less good, and that the complexion becomes pasty and less florid and clear. There was a striking case of this kind in the son of a medical friend, who watched his son naturally very carefully, and who told me that the effect of the tobacco (a good deal was smoked) was quite unmistakable. I persuaded the son to lessen his tobacco one half, and his health certainly improved, but he was then a young man. That some injury, therefore, is sometimes produced, and especially on young people, seems to me quite clear; but it is curious, in other cases, how difficult it is to find ill effects, even in the young, when the quantity is not excessive. As to the effect on the young even, it is curious in Burmah to see children smoking in their mothers' arms; and yet when I was serving in Burmah, many years ago, I often saw a woman walking along smoking her cigar of tobacco rolled up in a plantain-leaf, and carrying on her hip her child of two or three years old, who also had his or her little cigar, which was smoked with the greatest gravity. On talking to the Burmese (who smoke constantly), they would never allow that even young children were in the least damaged. When I was in Turkey I tried to make inquiries of some of the intelligent Turkish gentlemen; one or two of them said that they thought the Turks had learned to smoke from the Europeans, and had been growing apathetic and dull ever since. But others laughed at this, and the rural Turk, who smokes a good deal, is a fine, active, energetic fellow. I have talked to many Germans, who all stand out manfully for tobacco. In conclusion, I confess myself quite uncertain. I can find nothing like good evidence in books; too often a foregone conclusion, without any evidence to back it, is given. I think we must decidedly admit injury from excess; from moderate use I can see no harm, except it may be in youth. My opinions are, you will see, very indefinite, and I would gladly see some really good evidence collected. If at any time you can send me any facts, I shall be very grateful.

Believe me, very sincerely yours,

E. A. Parkes.

Bitterne, Southampton, *January* 28, 1876.

Intoxicating Properties of the Hemp-Plant.—Mohammedans, Hindoos, and others, whose religion forbids them the use of alcohol, find in this plant a substitute which, though not so pleasant to the taste, is on the whole far less injurious in its habitual use. It is taken in various ways. Mixed with tobacco, it is smoked in the hookah, and, to those unaccustomed to it, smells abominably. It is also taken in decoction, and in a solid form in sweetmeats. In ordinary doses it acts as a gentle and pleasant stimulant, exciting none of the brutal coarseness produced by alcoholic excess. In larger quantities it appears to banish all sense of fear, and is often taken by the Indian sepoy before entering into action; and Mohammedan fanatics brave death under its influence. On account of this property, the Afghans are reported to have used it freely in their recent war with the English, many of the fierce onslaughts made by small parties of natives on the foreign soldiery being traceable to its effects. When taken in excessive quantities it produces a form of madness, characterized by a reckless passion to destroy every living thing that comes in the maniac's way. It is related of an English officer at Delhi that, desiring to try the effects of hemp on himself, he inadvertently took an overdose, and bareheaded, on a scorching day in May, rushed down the road, armed with a large knife, and fiercely attacked a bullock, which was the first thing he met. He was quickly secured and disarmed, and, under the care of the doctor, who shaved his head and applied ice, was soon brought to his senses again.

Common Sense in Emergencies.—The story is told of Brunel, the eminent engineer and builder of the Thames Tunnel, that one day, while amusing a child with tricks of sleight-of-hand, he attempted one which resulted in a serious accident to himself, and at the same time illustrated the danger of playing pranks with the mouth. The trick consisted in adroitly concealing a half sovereign in his mouth and pretending to bring it out at his ear. All at once to his dismay the coin slipped down into his gullet, and there stuck in spite of every effort, surgical or otherwise, to dislodge it. In this dilemma common sense came to the rescue. Brunel himself devised an apparatus to which he was strapped head downward, keeping his mouth open, when, to his inexpressible relief, the coin dropped from its dangerous position and rolled out upon the floor. A sword-swallower, who once lost a bayonet in his throat during one of his public performances, resorted to similar means for recovering it, and was equally successful.

Passivity of Iron.—It has been observed that iron which has been treated with concentrated nitric acid assumes a passive state and refuses to be acted upon by the common or diluted acid, but the cause of the property has not hitherto been satisfactorily explained. M. Louis Varenne reported recently to the French Academy of Sciences that he had remarked that passivity was destroyed and the metal could be made to yield to the solvent action after a shock or jar was given to it, or a current of carbonic acid or hydrogen gas was passed over it. He was led to believe that an envelope of gas was formed around the metal which protected it, and, on examining some passive iron, found that it was actually covered with a layer of gas. The metal was then placed in a receiver and a vacuum was produced, with care not to touch the iron or disturb it in any way, after which it was plunged into the diluted acid, when it was readily attacked. The nature of the protecting gas was ascertained by introducing a little air into the exhausted receiver, when the orange color characteristic of the nitrous vapors was observed. The gaseous sheath is, therefore, chiefly composed of the deutoxide of nitrogen.

NOTES.

The Berlin Geographical Society recently celebrated the birthday anniversary of Carl Ritter, the famous German geographer. He founded the society in 1828, and presided over it until 1860. The university, the army, and various German societies, were largely represented, and handsome subscriptions were announced for a memorial to the hero of the evening.

The death is announced, on the 19th of December last, of Francis Boll, Professor of Comparative Physiology in the University of Rome. Though young, Professor Boll had contributed effectively to the advance of medical science by his physiological researches.

It has been a mooted question among physiologists whether saliva is destroyed in the gastric juice, or whether it continues its activity upon starch in the stomach. Recent researches by M. Defresne seem to prove that saliva is rendered entirely inactive in pure gastric juice; but that in gastric juice combined only with organic acids the conversion of starch into sugar proceeds as in the mouth.

It is announced that Leibnitz's calculating machine has been found. During his stay in Paris, in 1672, Leibnitz invented and constructed this machine, which was the wonder of the time. It can add, subtract, multiply, and divide. It early became the property of the Hanover Public Library, but long since disappeared from its treasures. Nothing was known of its whereabouts, except that it had been sent to an instrument-maker at Göttingen to be repaired. Through the efforts of Dr. Bodemann it has again come into the possession of the Public Library at Hanover.

The "Pall Mall Gazette" is authority for the statement that California whalers returning to San Francisco report the death by starvation of large numbers of Esquimaux in the vicinity of Behring's Strait. This is ascribed to the scarcity of walrus-meat, caused by the indiscriminate destruction of these animals by American whalemen—as many as a hundred thousand a year, it is said, having been killed by them.

Mr. Billin, in a paper on the preservation of timber, read lately before the Engineers' Club of Philadelphia, stated that creosoted ties in use for twenty and twenty-two years in England were still in as good a state of preservation as when first laid down. Creosoted piles driven at Portsmouth, England, forty-two years ago, were now as good above as below the water-line, and have outlasted sixteen sets cut from the same timber, and driven in the same work, but which were not creosoted.

M. J. Bernáth writes to "Nature" that our knowledge of the mineral waters of Hungary is altogether fragmentary and imperfect in kind. In the interest of truth he points out that a work, bearing the title "Les Eaux Minérales de la Hongrie," published under the auspices of the Hungarian Commission of the last Paris Exhibition, is altogether unreliable, and, in support of this opinion, states that the book enumerates less than forty per cent. of the localities in Hungary at which mineral springs occur; and, of the analyses published in the book, only those made twenty or thirty years ago find a place, the more recent and valuable ones being entirely omitted.

John Mears, F. R. S., whose botanical researches in South America, begun over fifty years ago, gave him a distinguished place among the botanists of England, died in London, October 17, 1879, aged ninety-one years. In 1825 he published "Travels in Chili and La Plata," and in later years contributed many interesting and valuable botanical papers to the "Transactions of the Linnæan Society." He bequeathed his herbarium of South American plants, numbering over 20,000 sheets, original drawings and manuscripts of his published works, and also some unpublished manuscripts, to the British Museum.

CHARLES F. CHANDLER

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PROGRESS AND POVERTY.

By C. M. LUNGREN.

THE most obvious fact in the industrial life of to-day is the enormous increase of productive power over that of any previous period. Steam and electricity have transformed civilization, endowed us with vaster powers, and altered profoundly the conditions of life. Things that could not have been done at all, things that could only have been done slowly and laboriously by unaided human exertion, have been done with swiftness, exactness, and certainty by the agencies created by human thought and skill. Things that were among the undreamed possibilities are now among the commonplaces of our lives. Machinery, dividing labor to an almost infinite degree, has multiplied its effectiveness manifold. The railroad and the telegraph, bringing men into closer and more intimate relations, have incalculably facilitated exchange. As a result of this greatly enhanced power of production, the accumulation of wealth has gone on at an unexampled rate. Enterprises, however great, need no longer fail for lack of the requisite capital. Works can now be undertaken that in a former age would have seemed and would have been utterly chimerical. We no longer feel that it would be useless to invent railroads because of the immense capital needed to build them.

With this increase of wealth and productive power great ameliorations have been expected. It has been the guiding and dominant faith of this era of remarkable material progress that these new agencies would steadily tend to lift all classes to a plane of greater material comfort. With productive power outrunning consuming power, there would be enough for all. Wealth would become equalized, so that each would receive a share of that produced proportional to his contribution to the common stock. The chasm between the very rich and the very poor would be bridged. Human powers, no longer the slaves of material needs, would have room to grow; human life, relieved of want and the fear of want, could expand indefinitely in grace and beauty. With time, however, this faith, if not shattered, has been weakened. Improvement has followed improvement, but it has not become easier to make a living; the difficulty rather increases. Wealth has shown no tendency to become diffused, but rather one to aggregate into comparatively few hands. In spite of all this wonderful advance, wages tend steadily to a minimum; and to the lowest class of society—the class that is just able to live—there is little promise of better things.

With the growth of industrial organization in complexity and variety, the increasing strife between employers and employed, the frequent recurrence of periods of business depression, which exhibit in an exaggerated form simply the ordinary conditions of industrial life, the question of the right relation of labor and capital to each other and to the industrial fabric presses with increasing strength for an answer. Employer and employed alike feel that there must be something amiss in an industrial system in which, with want unsatisfied, labor can find no employment and production no market; in which, with increase of productive power, poverty finds no abatement. And the importance of the question is in proportion to its persistence. Beside it all other questions sink into comparative insignificance. For all other progress is inextricably bound up with that of material welfare. It is idle to expect the growth of better conduct or of higher feelings in the man whom want stares in the face. Purer surroundings, better food, greater comforts, some relief from unremitting toil—these are the essential conditions of an improved life. Why poverty persists is the fundamental social question of our time, and must be of all times, until it receives a complete and satisfactory answer.

A thorough consideration has recently been made of this question, and a remarkable answer returned—an answer that finds the solution of the problem in a direction where most people would least expect to find it. In "Progress and Poverty" Mr. Henry George has made a careful and systematic inquiry into the conditions of the production and distribution of wealth, the relations of labor and capital, and has traced out the action of what he considers the cause of the continued association of poverty with advancing wealth. However unpalatable its conclusions to certain large classes of the community, this book must, from its clearness of statement, ingenuity of argument, its large human sympathy, and the broad and philosophic spirit with which the question is treated, claim the attention of all who realize the paramount importance of the subject and the value of a thoughtful contribution toward its elucidation.

Mr. George holds that the causes which determine the persistence of poverty are a part of those which produce progress, and not extraneous forces which progress tends to overcome. In support of this he points out certain facts which, though frequently noted, have received a different interpretation. "When the conditions," he says, "to which material progress everywhere tends are most fully realized —that is to say, where population is densest, wealth greatest, and the machinery of production and exchange most highly developed—we find the deepest poverty, the sharpest struggle for existence, and the most enforced idleness. It is to the newer countries—that is, to the countries where material progress is yet in its earlier stages—that laborers emigrate in search of higher wages, and capital flows in search of higher interest." It is here that, "though you will find an absence of wealth and all its concomitants, you will find no beggars. There is no luxury, but there is no destitution. No one makes an easy living, nor a very good living; but every one *can* make a living, and no one able and willing to work is oppressed by the fear of want." Such facts, Mr. George thinks, justify the belief that somewhere in the industrial fabric there must be a fundamental wrong—a social maladjustment that with increasing force, as progress proceeds, tends to continue and deepen poverty.

His inquiry, in which he has taken nothing for granted, but has examined anew all the doctrines of our current political economy, has led him to the conclusion that the primary cause of the low returns to labor and capital is to be found in the private ownership of the land of the earth, which is by right the common heritage of all. He rejects the common notion that there is an antagonism between labor and capital, and holds, on the contrary, that they are both robbed of their full earnings by the landholder. Labor can only produce wealth by having access to the materials it is to fashion, all of which are drawn from the earth, and by having such opportunities to occupy the land as its needs require. Whoever, then, can claim a right to the land can name the conditions upon which these materials can be obtained and this occupation allowed. Whoever commands the land commands the fruits of labor spent upon the land. Before labor can exert itself it must ask permission, and the price of this permission is the tax that, acting with accelerating power as civilization goes on, denies to labor and capital their rightful share in the wealth they have produced.

In claiming that private property in land is a wrong, Mr. George is not alone. He has with him the best thought of all times. Nearly every economist and social thinker of eminence who has made an investigation into the basis of property has found no warrant for the private ownership of land. They have all seen that a natural agent, which is necessary to human existence, and which can neither be increased nor decreased by human exertion, can by no process whatever become the rightful property of one man or any number of men, save all men. And most have seen that to finally settle on an equitable basis this question of the ownership of land will be, as Mr. Spencer says, "one of the most intricate problems society will one day have to solve." But though the inequity of private property in land has been so generally seen, and though it has also been seen that grave practical injury must result from such a wrong, no one, so far as I know, has before attempted to follow out the effects of this wrong in all the ramifications of industrial society. To understand in any way adequately Mr. George's position, the arguments which support his conclusions, and the facts which he has brought to bear upon the question, a study of his book is necessary; but some idea may be gained of the character of his inquiry, though none of his interesting and graphic treatment, by such an outline as can be here given.

Land and labor are the two factors from whose union springs all wealth. Land is the storehouse of all materials, and the place on which all labor must be exerted. Labor is the force which unceasingly shapes these materials into forms suited to human use. Between these two factors all the wealth created must be divided. Labor may, however, be separated into two forms, past and present, or capital and labor. The division of wealth, then, is between land, capital, and labor. The respective shares of these factors are rent, interest, and wages.

Before proceeding it will be necessary to determine the meaning Mr. George attaches to some economic terms used. In an economic sense labor is all human exertion in the production of wealth. Wages is the return made to this exertion. The payment received by the hired laborer, the clerk, or the professional man, the game of the hunter or the gold of the gold-digger, are equally wages. The kind of work done, or whether the work is done for one's self or for some one else, does not affect the character of the compensation. Whatever is recompense for exertion is wages. As to the meaning of capital, economists are not so well agreed. Mr. George defines it as "that part of wealth used to obtain more wealth"—the part in the hands of the producer to be devoted to productive uses. The term "wealth" Mr. George confines to those things whose destruction would decrease and whose increase would augment the aggregate possessions of a community. Bonds, mortgages, etc., when they are between the members of a community, are not, in this sense, wealth. By land is to be understood all natural capabilities, which are a gift to man. It includes fertile fields, ore-deposits, water-powers, the air, the sea, etc. Rent is the compensation received by the owner of any of these natural capabilities for their use. In ordinary speech the term is used to express the return for the use of some of the products of labor and capital, such as houses, improvements made on land, machinery, etc., but as used in economics it excludes the return made for any of these things. Return for the use of such things is properly interest on capital; return for the use of those things freely given by Nature to man is alone rent.

"The cause," says Mr. George, "which produces poverty in the midst of advancing wealth is evidently the cause which exhibits itself in the tendency, everywhere recognized, of wages to a minimum." The inquiry can therefore be put in the form, "Why, in spite of increase in productive power, do wages tend to a minimum, which will give but a bare living?" The answer given to this question by economic science has been the wage-fund theory. This theory holds that wages are determined by the ratio of the number of laborers to the capital devoted to their employment. As capital is the result of saving, industry can proceed no faster than this saving is effected. The wage-fund remaining the same, any increase in the number of laborers means a decrease in the share of each, and the reverse. The increase in the number of laborers constantly tends to overtake and surpass the increase in capital, and hence wages steadily tend to the minimum upon which laborers will consent to live and reproduce. The theory in this form is now pretty generally abandoned, but, as it is still held that wages are advanced out of capital, Mr. George considers that the abandonment is more nominal than real. On the contrary, he holds that wages are never advanced out of capital, but are drawn from the product of the labor for which they are paid. Labor creates wealth, and it is not until this wealth is created that labor receives its wages. The stock of capital on hand is never diminished by having to be paid for labor, but labor, as it goes along, creates the stock from which it is paid. Of the facts out of agreement with the wage-fund theory one of the most obvious is, that wages and interest do not vary inversely. By the theory, wages should be high where capital is abundant, and low where capital is scarce. The very reverse, says Mr. George, is true. Wages and interest rise and fall together. Labor moves for higher wages where capital flows for higher interest. Wages are high in new countries where capital is scarce, and low in old ones where it is abundant. This fact is generally noted by economists, but it is explained by them as due to the relatively greater production of wealth in new than in old countries. This, Mr. George holds, is demonstrably untrue.

The wage-fund theory also teaches that labor engaged in production is maintained out of present capital—that is, that present labor is subsisted on the product of past labor. This, Mr. George holds, is as baseless as the doctrine that wages are paid out of capital. He maintains that it is not at all necessary that there should have been a previous production of wealth sufficient to maintain the laborer. "It is only necessary," he says, "that there should be, somewhere within the circle of exchange, a contemporaneous production of sufficient subsistence for the laborer, and a willingness to exchange this subsistence for the thing on which labor is being bestowed." A government, when undertaking a work of years, does not collect a stock sufficient to support the laborers until the completion of the work, but it appropriates the subsistence necessary from present and future production, taking it in the form of taxation. No part of the world really lives on past production—that is, out of the savings of past labor. The whole world really lives from hand to mouth. Let the entire production of any great city be stopped for a day, and it would become evident how entirely men are dependent upon present production. The worker, therefore, on any prolonged enterprise does not draw his subsistence from past labor. He simply draws from the present amount of wealth a certain part in one form after he has added to present wealth a certain amount in another form. "The series of exchanges which unite production and consumption may be likened," says Mr. George, "to a curved pipe filled with water. If a quantity of water is poured in at one end, a like quantity is released at the other. It is not identically the same water, but is its equivalent. And so they who do the work of production put in as they take out—they receive in subsistence and wages but the produce of their labor."

Capital, then, neither pays the wages of labor nor subsists laborers in production, yet it has a function in production. This function is, holds Mr. George, to assist labor by providing it with better tools; by enabling labor to avail itself of the reproductive force of nature, as to get corn by sowing it, etc.; by allowing the greater division of labor, and thus vastly increasing its efficiency; and by holding and distributing the results of labor through exchange. To make exchange perfect there must constantly be great stores of goods in warehouses, ships, and railroad trains—goods held to supply the market, and goods on their way to market. To make labor effective, there must be many and various tools, factories, engines—all sorts of machinery. These tools and these goods in the hands of the producer are capital. Capital may limit the form and productiveness of industry by not supplying these tools or not rendering it this service in exchange, but to do this is a vastly different thing from limiting the exertion of labor, which is what the current doctrine teaches.

The wage-fund theory of the relations of capital and labor thus proves upon analysis to be untenable. The theory is and has always been weak. It has gained its ascendancy and almost universal acceptance, not from its own strength, Mr. George thinks, but from other considerations. Behind this theory stands another theory, that offers an explanation of continued poverty, and that fits into the other so as to lend it support in all directions. This theory is the Malthusian doctrine of population. This doctrine is, that population tends to increase faster than the means of obtaining food. Population presses with greater and greater force against the limit of subsistence. The limit is not a fixed but an elastic one, and the pressure exhibits itself in an increasing difficulty in procuring a living, and in that degree of want that will always keep population within the bounds of subsistence. How this and the wage-fund theory mutually support each other is evident. "According to the current doctrine of wages," says Mr. George, "wages fall as increase in the number of laborers necessitates a more minute division of capital; according to the Malthusian theory, poverty appears as increase in population necessitates the more minute division of subsistence. It requires but the identification of capital with subsistence and number of laborers with population to make the two propositions as identical formally as they are substantially." Mr. George does not deny that the capacity of the earth to support life is limited, and that there are, therefore, bounds to the population that can exist, but he does deny that there is any tendency of population to outrun subsistence, or that there has ever been any historic instance of a people unable to continue from such a cause.

In support of this view Mr. George reviews the condition of China, India, and Ireland, to find that in none of them population has yet pressed upon the means of subsistence so as to decrease the relative production of food, or to increase poverty, vice, misery, and crime. The lower animals, indeed, may press against the limits of subsistence. They can only take such food as can be found. With man the case is widely different. By breeding he can take advantage of the greater rate of reproduction of the lower animals and of the reproductive rate of plants. His powers of producing food may be indefinitely expanded, while his rate of reproduction is in the course of civilization not increasing. Historically the doctrine is not found to be true, and it is not consonant with many of the facts of observation. The essence of the doctrine of Malthus is, that the power of producing wealth does not keep pace with population—that in a dense population the power of producing wealth is proportionately less than in a sparse one. It may be objected that "the power of producing wealth" should read "the power of producing food." But, so long as the *whole* earth can supply enough food for the whole of its inhabitants, the power of producing wealth in any community is equivalent to the power of producing food, because, in consequence of a multitude of exchanges, wealth commands food. That a dense population produces less wealth per member than a sparse one is glaringly at variance with the facts. It is in the very densest population that this power increases enormously in proportion to the number of people. It is to effect this result that all the labor-saving machines exist and all the appliances of exchange have been called into being.

The Malthusian doctrine of population and the wage-fund theory of the relations of labor and capital being disproved, the ground is cleared for a consideration of what their true relations are.

As before stated, all wealth produced must be divided between three things—land, labor, and capital. The shares of these factors in production must stand in some relation with each other, such that two of them being given the other is determined, or that, one being given, the joint share of the other two is determined. In current economic doctrine there is no correlation between the laws determining the shares of these factors, and the nomenclature does not clearly or correctly express the shares into which wealth is divided. It is common for economists to speak of the division into rent, wages, and profits.

Rent clearly expresses the return made to landholders for the use of the land, and wages the return made for exertion of whatever kind; but profits does not express the return made for the use of capital. It includes, as well, that return made for labor in guiding and directing a business, commonly spoken of as the "wages of superintendence," and also the return for risk of capital. Wages of superintendence properly belong under wages, and, considering the entire field of industry, risk is eliminated. There is then left interest, which expresses all and no more that is properly the return made for the use of capital. The division of the produce is, therefore, into rent, wages, and interest. The laws of each of these will be found to correlate, and this interdependence is presumptive of their truth.

What, then, is the law of wages? In a primitive state of society, or in any of those simple occupations where a man works for himself, without calling in the use of capital, the whole result of his labor constitutes his return—his wages. The man who picks berries, hunts, or fishes, evidently has the berries picked, the game obtained, and the fish caught as the reward of his exertion. The wages of any number of laborers would be the whole amount produced, and the share of each would be proportional to the amount his labor contributed to the general stock of produce. But labor can not proceed very far before tools become necessary. Instead of all the labor being devoted to the things that are desired for consumption, part of the labor must be devoted to making tools that will facilitate the production of the things desired. These tools are capital, and the whole produce now obtained by the joint action of labor and capital will not go to labor alone, but will be divided between the two. Mr. George holds that interest is due simply to the value that the vital or reproductive forces of nature give to the element of time, the return for capital in any form being averaged with the return to capital in those forms in which these forces come into play. The constant tendency is to an equation between interest and wages, so that the return to capital and labor will be the same for the same work done. Labor and capital, therefore, would divide up between them the entire produce resulting from their union, each having a share proportionate to its contribution to the whole. But they are not permitted to make such division. A third party claims a share—the landholder.

If one man owned all the land that was open to capital and labor, he would have absolute control over the produce of these agents. He could take, if his authority were respected, any part of it, or all of it, as he was inclined. In actual industrial society, however, land is in too many hands to enable the owners to get whatever share of the produce they please. Competition determines the rate at which different lands will rent. The law, which in a condition of free competition determines this share of the landholder, is known as the law of rent. Though not first stated, it was first prominently brought forward by Ricardo. As formulated by him, it has been accepted by every economist of position since his time, and is one of the few doctrines of current economics that in the conflict of opinion have remained unshaken. Mr. George regards it as axiomatic, the terms having only to be correctly apprehended in order to meet with acceptance. This law is that the rent of land is determined by the excess of produce over that amount which the same application of labor and capital will obtain from the least productive land in use. The returns to capital and labor do not depend solely upon the amount and effectiveness of each, but they also depend upon the productiveness of the land upon which they are applied. When lands of different degrees of productiveness are open to them, they will apply themselves to the most productive, and their return will be the entire produce resulting. As land less and less productive remains open to them, the amount that they can produce on it decreases. Hence, on account of the competition for the more productive lands, land-owners are able to appropriate to themselves all of the produce obtained above that which the same labor and capital can obtain from the least productive land in use—the most productive free to them. The law, of course, applies to all lands used for any purpose whatever, though in the current statement of it too exclusive attention is generally paid to its relation to agriculture.

The relations of the shares of the three factors in production may be shown more clearly in the form of an equation: Produce = rent + wages + interest, or produce − rent = wages + interest. How rent affects industry is now evident. The laws of both interest and wages appear as corollaries of this law of rent. For this law states that, no matter what the productive power of labor and capital, these two agents can only receive in wages and interest that part of the produce that they could have obtained on land free to them. The reward of labor and capital does not depend upon what they have produced, but upon what is left after rent is taken out. "The moment," says Mr. George, "this simple relation is recognized, a flood of light streams in upon what was before inexplicable, and seemingly discordant facts range themselves under an obvious law. The increase of rent which goes on in progressive countries is at once seen to be the key which explains why wages and interest fail to increase with increase of productive power. . . . When production increases, as it is increasing in all progressive countries, wages and interest will be affected, not by the increase, but by the manner in which rent is affected. If the value of land increases proportionally, all the increased production will be swallowed up by rent, and wages and interest remain as before. If the value of land increases in greater ratio than productive power, rent will swallow up even more than the increase; and, while the produce of labor and capital will be much larger, wages and interest will fall. It is only when the value of land fails to increase as rapidly as productive power that wages and interest can increase with the increase in productive power."

The conclusion reached by Mr. George as to the laws which govern the distribution of wealth may now be stated in such form as to show their relation to each other, and to contrast them with the laws as taught by current economics. According to Mr. George—

"Rent depends on the margin of cultivation, rising as it falls, and falling as it rises.

"Wages depend on the margin of cultivation, falling as it falls, and rising as it rises.

"Interest (its ratio with wages being fixed by the net power of increase which attaches to capital) depends on the margin of cultivation, falling as it falls, and rising as it rises."

As taught by the economists, rent is the same.

"Wages depend upon the ratio between the number of laborers and the amount of capital devoted to their employment.

"Interest depends upon the equation between the supply of and demand for capital; or, as is stated of profits, upon wages (or the cost of labor) rising as wages fall, and falling as wages rise." The wide difference between the two sets of laws thus contrasted is evident. In the laws as generally taught there is no mutual relation by which they are all bound in a single whole. As stated by Mr. George, on the contrary, they all correlate with each other, and form a complete whole.

The conclusions embodied in these laws are: That, where land is free, labor when unassisted by capital will take the whole produce; that where it is assisted by capital it will take the whole, less the amount necessary to induce the storing up of labor as capital; where part of the land is appropriated, labor and capital will receive what is left of the produce after the deduction of rent, or what they could have produced on land free to them; when all land is appropriated, the return to labor and capital can be forced to the limit on which these factors will consent to reproduce. This being the relation between the three factors in production, it remains only to see the manner in which increase in population and improvement of the arts affect rent, to understand the full effect of the force that presses so continuously upon industry.

While Mr. George allows the effect that increasing population would have in increasing rent by lowering the margin of cultivation, he yet thinks that this is not the main way in which it affects rent. As population increases in any community, certain land—land at the center of trade and production—acquires new powers, an increased productiveness. Labor spent on this land can produce results not only vastly greater than it could on land beyond the boundaries of this population, but results that it could not produce at all beyond those boundaries. As the village grows into the city, the nearness of men to each other, the division of labor that becomes possible, the greater economies that follow in consequence, the immense facilities of exchange, increase the effectiveness of labor exerted in the center of population enormously. Here is the market to buy and sell ; here the services of the professional man, the tradesman, of any and everybody, become of much greater value to them than they could possibly be elsewhere. Instead of a few men working over a piece of ground, here are multitudes of men to the acre, on floors one above another, producing vastly more than the same number could over a wider area. All these advantages adhere to the land—to this particular land in the center of industry, and these advantages have to be paid for. By the law of rent, all the produce resulting from this increased effectiveness of labor and ease of exchange—that is, more than what the same labor and capital could procure on land free to them—goes to the landholder. Population, then, as it becomes dense, enormously increases rent.

And the increase of improvements in the arts affects rent in the same way. All labor-saving machines can affect production in one of two ways. Production may remain the same, and a certain amount of labor be set free, or the same amount of labor may be used, and production be increased. In an active civilization like ours, the main effect will be in the latter way. For, by the conditions of industry, labor can not take advantage of its increased effectiveness by resting, but must press for employment, and hence the effect of labor-saving devices will be to increase the wealth produced. But to the production of wealth land is necessary, hence the demand for land must constantly increase, steadily forcing down the margin of cultivation. Thus, without any augmentation of the population, rent is advanced.

In the speculative rise in the value of land, there is a further force acting in the same direction as these others. In every growing community there is a confidence that land will increase in value, which leads to the holding of land for such increase. This speculative rise in the value of land shows itself in higher rents.

In this speculative increase of land-values, Mr. George finds the *primary* cause of those periodic depressions of industry which we term "hard times." The essential feature of such a period is the circumstance of numbers of men, able and willing to work, seeking employment vainly ; great masses of capital lying idle ; quantities of goods in warehouses and stores unsalable. It is not that productive power has been too active ; it is not that consumption has been too great. The over-production and over-consumption theories have never been satisfactory. Economists have seen that, as the very object of industry is to produce wealth, there can never be too much wealth, and men generally have seen that the desire for consumption is not lessened. They have all felt that the difficulty lay rather with a choking of exchange. There has been a hitch somewhere by which production and consumption could not meet and satisfy each other. Looked at closely, an industrial crisis always reveals the fact that there has somewhere been a check to production. These producers stopping, their demand for the things they consume ceases, and the check is thus rapidly propagated throughout the entire industrial organization, cessation of demand resulting in cessation of supply, and this in turn manifesting itself in a new cessation of demand. It is not necessary that production be really less, but only less relatively. In an advancing community, the failure of production to increase proportionally would have the same effect as decreasing production in a stationary one. How, then, is this check in production brought about? If we trace it from one point to another, we shall ultimately find it in some obstacle which checks the expenditure of labor on land. The speculative advance in rent crowds down wages and interest to the point at which they will no longer consent to reproduce, production ceases, and the effects of this stoppage are propagated throughout the entire framework of industry. Deduction from the law of rent shows that unchecked rise in rent must show itself in an industrial crisis, and the facts, he holds, abundantly support the deduction. Production may be likened to a steam-engine and rent to its governor. A lightened load, an increased pressure, and the engine bounds forward with accelerating speed. But the power that drives the engine drives also the governor; the force that has doubled the speed is the force that must ultimately check it—the governor, overtaking the engine, throttles the power that gives it action. And so in endless repetition.

Here, then, is the explanation of the facts that mystify and perplex whoever considers them. Here, then, in the relation of rent to wages and interest is the primary cause of the failure of invention and discovery to benefit the workingman. Wages and interest steadily tend to a minimum, but the incontestable fact in material progress is the rise in land-values. The great machinery of modern industry does not benefit labor and capital, because it does benefit the landholder. So long as men can control the land which all must use, they can command all the fruits of labor above what is necessary to a bare living.

"Everywhere, in all times, among all peoples," says Mr. George, "the possession of land is the base of aristocracy, the foundation of great fortunes, the source of power. As said the Brahmans ages ago—'To whomsoever the soil at any time belongs, to him belong the fruits of it. White parasols and elephants made with pride are the flowers of a grant of land.'"

Mr. George does not think that he can be said to have advanced any theory, but that he has only pointed out the most obvious relations. Taking the accepted law of rent, he has only insisted that, where the whole produce is between three factors, the law that determines the share of one *must* necessarily give the share of the other two. He has only pointed out that, if rent takes all above a certain amount, wages and interest can't have more than this amount.

The fact that the laws of wages, interest, and rent must be mutually dependent, Mr. George thinks so evident, that he marvels that so many acute thinkers could have failed to grasp the proper relations. He is even tempted to believe that some have seen, but, seeing also the enormous consequences, have turned away, remembering that "a great truth to an age which has rejected and trampled on it is not a word of peace, but a sword!"

In finding the cause of the persistence of poverty in the continuous advance of rent, the remedy is at the same time found, and Mr. George does not hesitate to apply it. He would make land common property. He reviews all the remedies proposed and finds none save this sufficient. No alleviation would follow from a decrease of the expenses of government, as this would be equivalent to an increased production, of which the landholder would take all the gain. Education and habits of industry can increase the laborer's share in production to only a very limited extent. Such qualities are like speed in a horse—it is only available in so far as it exceeds that of its competitors. Better material condition, it is true, is usually associated with the possession of such qualities, but the condition is the cause of them and not they of the condition. Little, likewise, can be expected of combinations of workmen. They can, indeed, increase their wages by such means, and not at the expense of each other or of capital as is commonly supposed, but at the expense of rent; but they can do so in so small a degree that the effect is relatively unimportant. In any contest between employers and employed it is not a struggle between labor and capital, but between labor and the owners of land, and it must always be an unequal one. Such a contest is, moreover, a destructive one—a war which, like any other, lessens wealth. And the organization for such a war, as for any other, must be tyrannical. Contests of this sort are, therefore, destructive of the very things sought to be gained by them —"wealth and freedom."

The hopes of those who see in coöperation the instrument of industrial regeneration seem to Mr. George doomed to perpetual disappointment so long as land remains appropriated. If coöperation has any power at all, it is one analogous to an improved instrument of production, which can increase the amount produced, but can not augment the laborer's share in this amount. Governmental direction and interference can only, in the present state of industry, be mischievous and inefficient.

The remedy most counted on, by those who have seen, in a vague way, that there is some connection between industrial distress and land tenure, is the dividing the land up into small holdings. Mr. George thinks this both impracticable and undesirable, as well as inefficient. Land can not be so divided, and even if it could, it is against those tendencies that are born of and grow with civilization. Machinery applied to agriculture makes cultivation on a large scale more economical than on a small one, and such holdings would interfere with the most advantageous occupancy of the land. The plan, however, has the cardinal objection that, unless every member of a community was a holder of land of equal productiveness, it would not abolish rent, and would therefore have no tendency toward an equitable division of the produce. There therefore remains only the plan of giving to every one equal rights to the whole land—the plan of making land common property.

Mr. George dismisses the claim of the landowners to compensation. If they were paid the market price for the land, industry would not be relieved, as the tax would remain in the form of interest on the purchase-money. Such an arrangement would, of course, prevent the further tax upon industry caused by the future increase of rent, but still the main burden would remain. Injustice, Mr. George thinks, has and can have no vested rights. If it be a wrong to deprive the landowners of their land without compensation, it is a greater wrong to take from industry to pay them for a value that industry has alone created. It is a conflict of claims, and the lesser claim must be the one disregarded. He points out that, tried by the common law, which through all the ages has been built up and elaborated by the dominant class, the landholders, they would not only get no recompense for their land, but none for their improvements; and, further, that they would be called to account for the returns received during the time the land was held. Mr. George is, however, satisfied to waive this, and be content with the resumption of the land by society.

In carrying out his project of making land common property, Mr. George would disturb as little as possible existing industrial, social, and political organization. He does not think that it is either necessary or desirable to effect his purpose directly. It can be done better and with less shock to accustomed feelings and habits, and with greater economy of means, indirectly. His plan is very simple. He would place *all* taxes upon land. He would leave the titles to land in the hands of individuals to buy and sell, to let and hold the same as now, but while leaving the shell he would take the kernel, by confiscating rent. We now take some rent in taxation; he would take it all. This would pay all government expenses, and would increase rapidly enough to meet them as they increase, and to perhaps leave a surplus. Such an arrangement would result in an enormous simplification of government. It would take no more labor to collect land-taxes then than now, while all the cumbrous institutions now in use—custom-houses, internal revenue service, etc.—with their vast and demoralizing influence on political life and their prodigal waste, would be abolished.

Land can not be hid; its rent at any time is readily ascertainable, so that the Government would get a considerably larger percentage of taxation than now.

Mr. George tests his proposition by the accepted canons of taxation, and finds that the tax on land is the only tax which can not be distributed—which those taxed can not throw off on to others. It is, therefore, the only tax which does not bear upon production. This also follows from the law of rent, as the relation between the most productive and least productive land in use is not altered by such a tax, and therefore the share of labor and capital can not be affected by it. Under such tenure of land the burden of taxation will be raised from production, and, while it still pays rent, though a greatly reduced one, this goes to the state, to be used for the benefit of those who have created the fund.

Under such an arrangement, land would be improved as fast as there was a demand for it. No one, as now, could afford to hold land unless he proposed to use it. There would be no prospect of parting with it at a future time for more than now, while the holder would have to pay an increasing rent without any advantage accruing to him. This tax, therefore, would have the effect of forcing improvement instead of acting, as present taxation does, as a fine upon improvement. Nor need any fears be entertained that such a holding of land would deter men from improving it because they did not own it. Ownership is not necessary, as is shown by the many costly buildings in every city built upon leased land. All that is necessary is that there be security for the improvement.

Mr. George holds that, though the proposal to place all taxes on land is, at first sight, to increase the burdens of the farmer, it is not in reality so. At present he is taxed on all his improvements, houses, barns, fences, stock, and crops, while, through the action of the tariff, he pays enormous taxes on everything he consumes. Under the arrangement proposed all these taxes would be removed, and there would remain only the tax on the bare land. As speculative land-values would be abolished, and large tracts of land now held thrown open to improvement, the value of his land would decrease, with the result that, in sparsely settled districts, he would have little or no taxes to pay. The tendency of this measure would be to distribute population more equitably—to take from the overcrowded city and add to the thinly settled country. With the continued application of machinery to agriculture, farming life would tend to assume the form of the village community, whence the great gain to the farmer in the increased advantage of social intercourse. He would lose little or nothing in a pecuniary way, and gain much in an improved social life. And so with the owners of homesteads, and all land-owners whose interests as such do not greatly predominate over their interests as laborers and capitalists.

Of the effect of his remedy upon the material, social, and moral welfare of society Mr. George is very hopeful. Under its action he sees production bounding forward with giant strides; the great agencies, which man has called into being to help him subdue the earth, no longer of doubtful good. By the power of these "slaves of the lamp of knowledge" he sees wealth increased on every hand, and distributed to each according to his labor. He sees these great forces elevating society from its very foundations. Each would have enough and to spare. Men would no longer seek vainly for the opportunities to labor. Competition would no longer be one-sided. "Into the labor market would have entered the greatest of all competitors for the employment of labor, a competitor whose demand can not be satisfied until want is satisfied—the demand of labor itself." All raised above want and the fear of want, human life would expand in new directions and under the impulse of new ideals. The worship of wealth is but the expression of the fear of want. All men struggle to place themselves above want and the possibility of it. What men struggle for they admire, and to win the admiration and approbation of their fellows, if not the strongest, is at least one of the strongest, passions of human nature. With the passing away of this fear of want, however, will come a declining admiration of wealth, self-seeking diminish, seeking the good of others increase. And there need be no fear that, with declining need to devote his powers to getting subsistence, man will stagnate. "Man is the unsatisfied animal." For him are all the powers of the heavens and the earth. Beyond material needs there are spiritual needs.

That love of knowledge which has given us our sciences, of the beautiful which has given us our art and literature, will in the future as in the past appeal to and excite our highest powers. Whatever may have been the need of the stimulus given by the fear of want, it no longer exists. Humanity now needs but to be assured of the fruits of its labor to go upon the heights. It needs but this to realize the dream born of material progress—to make for itself the golden age:

"Youth no longer stunted and starved; age no longer harried by avarice; the child at play with the tiger; the man with the muck-rake drinking in the glory of the stars! Foul things fled, fierce things tame, discord turned to harmony! For how could there be greed where all had enough? How could the vice, the crime, the ignorance, the brutality, that spring from poverty and the fear of poverty, exist where poverty had vanished? Who should crouch where all were freemen; who oppress where all were peers?"

Such the promise Mr. George holds out to society if it but consent to "render unto Cæsar the things that are Cæsar's"—to give to labor and capital their reward. If it consent not, he raises his voice to warn it that it must crush the worm that is gnawing at its vitals, if it be not destroyed. If labor get not its reward, the gulf between the rich and poor must widen as material progress goes on; the mass of ignorance, of brutality, of recklessness, the number of those who are in our civilization but not of it, must increase and threaten its existence. The barbarians who will destroy our civilization come not from without but from within. "In the shadow of college and library and museum are gathering the more hideous Huns and fiercer Vandals of whom Macaulay prophesied."

Mr. George closes his book with a theory of progress in which heredity counts but little, and conditions much; whose law is association in equality. Men advance as they come in closer contact, and as the conditions of each are more nearly equal; and fail to do so or decline as these requirements are not met. Civilizations rise and fall, stop or turn back, or are transformed in obedience to this law.

I am not here concerned with criticising Mr. George's work, with pointing out the extravagance of his expectations; the fact that human nature is not nearly as easily modified as he assumes; that poverty is but one of the factors in the production of vice, misery, and crime; that far-reaching biological and psychological laws are not so readily set aside as he seems to think. These things do not affect the essential doctrine of his book—that, by the law of rent, rent must have a determining influence in the distribution of wealth. My purpose is served if I have succeeded in drawing attention to what seems to me one of the most important contributions yet made to economic literature.

WHAT IS JUPITER DOING?

By HENRY J. SLACK.

THE question, so often suggested by changes in the aspect of the planet Jupiter, "What is he doing?" is again forcibly put by the appearance of a remarkable spot of enormous dimensions, and of a reddish or orange-brown tint, which has occupied the attention of observers for several months, and which seems to be identified, so far as relates to position and form, though not in color, with what has been seen on former occasions.

Probably no celestial bodies reach a permanent condition: constant change seems a law of nature; but there may be great variations in the rates at which changes occur. If we assume as probable a modification of the nebular theory, suns and their attendant planets are formed by the condensation of matter in an extreme state of tenuity, and the mass of suns and planets may receive frequent additions in the shape of any smaller or less heavy bodies they are able to attract. Our sun is probably a great devourer of meteors; and, as our earth crosses the orbits of certain meteoric swarms, we have showers of shooting stars, fortunately so small that their bombardment is unnoticed.

Scarcely anything is known, or plausibly guessed, concerning the condition and properties of nebulous matter. If, for example, the

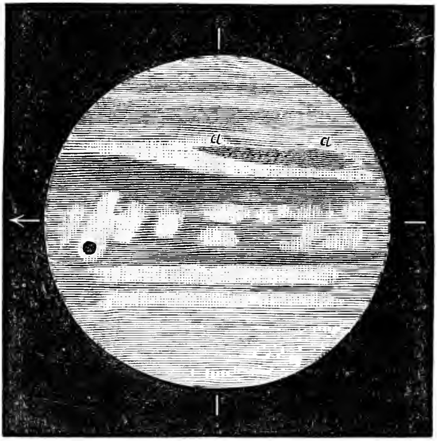

Fig. 1.—Spots on Jupiter observed and drawn by Mr. E. L. Trouvelot.—Observation of September 25, 1878, with the shadow of a satellite.

spectrum of a nebula indicates hydrogen, we may be pretty sure it is not in the state of the gas as it is known in our laboratories. The recent discoveries of Crookes concerning the properties of matter a million times more attenuated than common air lead to the hope that fresh light may be thrown upon many astronomical questions ; but in the mean time it is impossible to form more than a vague idea of the condition of any star or planet that does not in its main features resemble our earth ; and this can be said only of Mars, on whose globe we can discover what is probably land and what is water, and see white masses, which it is reasonable to believe are snow, form and melt away as the planet's winter and summer affect them in turns.

Our earth has long been in a state of slow, as distinguished from that of rapid, change. The geologist finds the oldest rocks he can discover affording indications that they were formed when the circumstances of the globe were sufficiently like what they are now for fair comparison. The earth's surface may have been warmer, its atmosphere more moist, and it may have contained more carbonic acid than we now find ; storms may have been more frequent and more violent, but the assemblage of differences between what now is and what was at the time of any formation the geologists can reach would not noticeably approach the enormous difference that separates the condition of our earth from that of either Jupiter or Saturn. It is possible that they now represent stages which our earth passed through in remote times, and they may be undergoing changes that are approximating

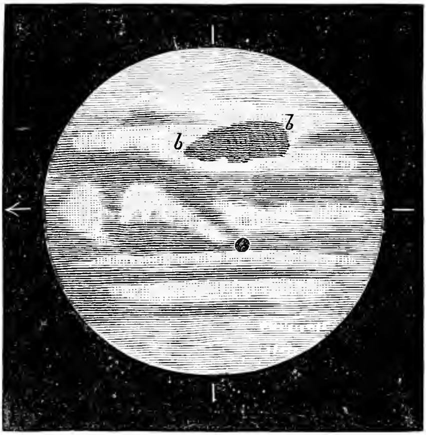

FIG. 2.—SPOTS ON JUPITER OBSERVED AND DRAWN BY MR. E. L. TROUVELOT.—Observation of December 23, 1878, with the shadow of the third satellite.

them to our present condition. It is, however, probable that, while there are analogies and resemblances in the life-histories of all the heavenly bodies, there are also individual peculiarities and diversities not less important or less striking.

Jupiter's diameter is about eleven times that of our earth, and his mean density is about a quarter that of the earth, or about a third more than water. Now, a bulky body may be composed of heavy materials, and still, as a whole, be light, like an iron ship or a lump of pumice-stone, that will float in water. The pumice-lump is light on account of its vesicular formation, so that the mass consists of heavy feldspathic material and the air it contains. Extract the air, and the pumice loses its floating power, though still far from heavy in proportion to its bulk. Most of the earth's crust is formed of solids much heavier than water. Granites are more than two and a half times heavier than water, slaty rocks much about the same, and so are ordinary limestones, the variations of all being from about 2·5 to 2·9. The ironstone group contains denser minerals ; red hematite has a specific gravity of 4·5 ; magnetic ironstone, 4·5 to 5·2, etc. ; and many other ores are heavy.

At some remote period, when only part of the now solid earth had been condensed from gaseous and vapory matter, our planet might have had a mean density like that of Jupiter, as its rocky materials contain between forty and fifty per cent. of oxygen; and while condensations and chemical combinations were going on rapidly our globe must have been the scene of

"Thunders, lightnings, and prodigious storms."

And it is probable that certain stars which have suddenly blazed forth with passing splendor have exhibited to us the spectacle of conflagrations extending over millions and billions of square miles. Color-changes in Jupiter—such as those noticed by Mr. Browning and the writer in 1869–'70—may have been caused by soda-flames, though not fierce enough or extensive enough to add materially to his ordinary luminosity, which is estimated as always exceeding, though not in a very high degree, what it would be by mere reflection of light received from the sun. A drawing after Mr. Browning was published in the fifth volume of the "Student and Intellectual Observer," showing a broad, full, yellow equatorial belt; also broad belts of purplish brown edged with narrower yellow bands above and below it, and curious white patches in the upper dark belt. The polar belts were purplish and olive. The appearance and disappearance of these remarkable belts indicated great physical changes, and it is to be regretted that spectroscopes could not afford so much information as was hoped for. The planet, though appearing much brighter than any star, gives, according to Mr. Browning, a spectrum fainter than that of a star of the second magnitude. It is the size of the planet and his nearness, as compared with the distance of any fixed star, that make him such a brilliant object. The size of a luminous body greatly affects our estimation of the intensity of its light. Mr. Huggins, at the time mentioned, discovered some dark lines in the Jovian spectrum not belonging to the solar spectrum, and probably resulting from the absorptive action of the planet's atmosphere. He also pointed out that the remarkable yellow color had been seen some years before. Quite recently Mr. Huggins has been employing his large reflector to take photographic spectra of the planet, and he informs the writer that "from G to O in the outer violet there is no sensible modification, either in addition or absence of lines, of the solar spectrum." This is curious, as Jupiter has exhibited a good deal of primrose tint, with orange-brown belts and a big orange-brown spot.

A telescopic view of Jupiter usually exhibits some dark belts, occupying a zone of considerable breadth, on either side of the planet's equator, with less conspicuous markings nearer the polar regions. It is also common to find various-shaped patches brighter than the rest. Sometimes the general pattern formed by these markings lasts for months with little visible alteration. At other times a few minutes are sufficient for changes of enormous magnitude. The first question that arises is, What do the dark bands or spots mean? Are they portions of the solid body of the planet, which have some fixity of shape, in any degree analogous to that of our mountain-chains or great continents? Or are they cloudy matter of less light-reflecting power than the bright and dense atmosphere by which the planet appears to be surrounded? Or are they merely more transparent parts of that atmosphere, through which no lower objects happen to reflect light enough to be visible? If the bright parts of the Jovian disk are light-reflecting clouds, and the dark belts the body of the planet, we should suppose it would be common to see a notched appearance of the edges; but this is not so. "Ordinarily," as Captain Noble says, "the belts fade perceptibly as they approach the actual edge of the disk; but," he adds, "I *have* seen the belts right up to it." The softening of the belts, as the planet's rotation brings them to the edges of the disk, probably arises from the dark parts being considerably below the boundary of the Jovian atmosphere, and thus seen through a greater thickness of it when near the edges. When the dark belts touch the edge without noticeable softening they must be higher up, and less likely to be any part of the solid body, if Jupiter has anything that can be so called. The great spot of this season has never been seen close to the edge. A very moderate magnification is sufficient to show that as the planet rotates it comes into view decidedly at some distance from the luminous margin, and disappears at a similar distance from the opposite margin.

Telescopes, under the most favorable conditions, and of the greatest power, only reveal very large features of the planet. It is impossible to see anything like details of structure, and this makes the identification of objects seen at different times more or less uncertain. If we had glimpses of great mountain-chains in Jupiter, it would be something like seeing the Andes or the Himalayas all in a lump, from some skyey perch, so far off as to prevent the separate peaks and valleys from being noticed. Jupiter is about five and one fifth times as far from the sun as we are—our mean distance, according to the last reckoning, being 92,620,000 miles. With the moon only 240,000 miles off, and very frequently bearing a much higher magnification than can be applied without confusion to Jupiter, telescopes bring no object near. A magnification of 1,000 linear—only usable under very favorable circumstances—makes lunar objects as big, but not as distinct, as a naked-eye vision of them would do if it could approach within 240 miles. With the enormously greater distance of Jupiter it must be evident how impossible it is for anything but huge masses to be seen.

Jupiter's atmosphere is much larger in proportion to any solid matter he may contain than that of our earth to its solid matter. It is also much denser, and from its greater distance only gets about one twenty-fifth as much solar influence as reaches us. For these and other reasons it is not unlikely that some of his cloud formations may be more lasting than ours. That his gaseous envelope is, however, at times subject to violent disturbances arising from a prodigious exertion of internal forces is proved by instances of sudden changes in the diameter of the disk. The Rev. T. W. Webb, in his "Celestial Objects," mentions as "inexplicable" an observation of Smyth, confirmed by similar observations of Maclear and Pearson, all being at different places, namely, that on June 26, 1828, Jupiter's second satellite, after fairly entering upon the disk, in the course of its revolution, was subsequently seen for four minutes outside it, and then suddenly vanished. More recently Secchi noticed a similar phenomenon; and the explanation can only be that Jupiter's atmosphere was suddenly blown out for some thousands of miles and retreated again. Secchi states that on April 2, 1874, he watched the first satellite as it was about to cross the planet's disk, which appeared "finely undulated." "When the satellite approached within its own diameter of the margin of the planet the latter sprang toward it, appeared to touch it, and immediately retired. This happened, backward and forward, until the satellite had plainly entered upon the planet; that is to say, for four or five minutes.* . . . The satellite appeared fixed, and all the movement seemed to belong to the disk of the planet."

In October, 1879, Mr. Kidd, of Bramley, Guildford, saw, as is described in the "Observatory" for November, the second satellite first touch the disk, then appear separated from it, and finally pass behind it, but remain for some time visible through it. The "Observatory" for November also quotes the "Chicago Tribune," to the effect that observations at the Dearborn Observatory indicate that changes in the outline of the planet take place from day to day. Two sets of measures at the interval of a week are stated to have shown a difference in the direction of the major axis amounting to 5°.

When extensive belts or bright portions change rapidly, the storm-effects must be immensely greater than in any of our hurricanes. Jupiter's motion at the equator is at the rate of about 28,000 miles an hour; his daily rotation is completed in a few seconds less than ten hours; and objects in Jupiter weigh about two and a halt times as much as on our earth. When our winds move with a hurricane-speed of 85 miles an hour, they exert a pressure upon whatever they strike equal to 36 pounds per square foot. What, then, must be the force of a Jovian storm, moving much heavier matter than our air, at the rate of 300 miles an hour, as was observed on one occasion by Herschels?

On another occasion South saw a spot 22,000 miles long, and before a friend who was present could commence a sketch it had nearly all changed. There may in such cases be violent chemical action, a terrific clashing together of atoms, and the precipitation of solid oxides of metals, like the fumes produced by the burning of magnesium wire.

* "Comptes Rendus," 1874, vol. lxxviii., p. 1468.

In considering the persistence of spots or markings, it seems that the dark ones are more lasting than the light. A dark spot noticed by Cassini in 1665 was visible up to 1713, though obscured at intervals—at one time for eight years.

Some interesting white spots were noticed in 1878 by Niesten, of the Brussels Observatory, to change from a circular to an elongated form as they appeared in the center or nearer the sides of the disk. This would indicate something like a columnar form, looking round when seen vertically, and elongated when seen aslant.

Lately, as already mentioned, a very fine dark spot has been seen upon the south equatorial belt. It was found by Niesten to be 13″ long, and 3″ wide, the polar diameter of the planet being 48″. When Captain Noble saw this spot, on August 22, 1879, he made a memorandum that "the remarkable spot sketched on November 19, 1858 (nearly twenty-one years ago), reappears—or one very similar indeed to it does—to-night."

M. Niesten kindly sent to the writer—who published a translation of it in the "Astronomical Register" for November—a list of observations of red spots more or less identical in aspect with this one, and probably of the same formation. It is not to be expected that in the revolutionary state of things existing in Jupiter there would be the same persistence of form that belongs to our islands and continents; and it is quite possible that there may be huge islands of vesicular formation, far bigger than all Australia, floating in viscous seas; so that if the figure of a spot remains the same, or spots seen at different times bear a strong resemblance to each other, they *might* be identical, even though there had been some change of place. Mathematicians tell us that the flattening at the poles noticeable in Jupiter and Saturn, and caused by their rapid rotation, would be greater than measurement shows, if such light bodies were homogeneous. There must, therefore, be some portions much denser than others, and these planets most probably contain matter in all intermediate stages, from the attenuated gaseous, through the viscid, to the solid. It must often happen, as Chacornac considered traceable in the sun, that condensation produces a great down-rush, and substances that have been solidified falling into hotter regions get melted up or vaporized again.

The great red spot lies like a continent some 24,000 miles long, surrounded by a rather narrow sea of light, and over it Niesten noticed two brilliant little spots which he appropriately named "pearls." There is a general concurrence of opinion that the big spot grew ruddier than when it first appeared, or rather richer in color; its "*redness*" has been chiefly caused by the want of achromatism in the telescopes employed. Glass mirrors silvered—which represent colors most correctly—show the tints to be orange-brown. The bright parts, as seen by the writer with a With-Browning silvered mirror and a fine prism, closely resembled the color of autumn beech-leaves in full sunlight. Some Merz telescopes add, from their defects, a purple tint; and an instrument of another maker gives the spot the color known as Venetian red. Dr. Pigott, who has a With-Browning silvered mirror instrument, and a fine refractor by Wray, finds the latter so unusually well corrected that its performance coincides closely with that of the former. Color-changes, both as regards time and intensity, may be caused by the greater or less translucency and refracting powers of the atmosphere through which any object is seen; but they may also very frequently arise from the greater or less heat and luminosity of solid or viscid matter below the cloudy strata, and from important modifications of chemical action. Between September 3d, at from 10.45 to 10.55 P. M., and October 4th, 10.40 P. M., Captain Noble's drawings, made at Maresfield, show a great change in the aspect of the planet, affecting the brightness and the tint of enormous spaces. Parts above the great spot which were brilliant on the former occasion had become cloudy, and, southeast of the spot, there came a round white spot, with very dark surroundings. These changes must have affected many millions of square miles.

On October 16th, at 10.5 P. M., he noticed the color of the red spot "more marked than ever." There were also extensive changes in the belts, and the polar regions were more cloudy. He made the following entry in his note-book: "It is a most noticeable feature; the red spot reposes like an island in the middle of a light space on the planet's disk, and the belts, north and south of it, seem in a great measure to conform to its curved outline. This would indicate a disturbance of a stupendous character, from the amount of the area involved."

On the whole, during the season for observation of 1879-'80 Jupiter has been more than usually interesting. From pole to pole changes of great magnitude have been produced with prodigality of violence rather than with economy of time. Perhaps the mighty planet is still in the stage of youth, with blazing and explosive energies that a few hundred thousands of years may be required to tame down to the soberness of our comparatively quiescent earth.—*Belgravia.*

[Note.—The red spot spoken of above was watched by an astronomer in this country, Mr. E. Leopold Trouvelot, of the observatory at Cambridge, during a part of 1878. He has published an account of his observations in "The Observatory," and has furnished to "La Nature" two views of the spot as seen at times three months apart, which we reproduce. In his published description, Mr. Trouvelot says that in looking at Jupiter on September 25, 1878, at six hours and fifty minutes, he noticed a remarkable red spot a little above the southern border of the equatorial belt, with its center situated a little to the east of the central meridian. It occupied apparently about one fifth of the diameter of the planet, and was quite distinct, its intense rose-color forming a striking contrast with the luminous white ground on which it was projected. It was of the same shade, uniform from one end to the other, without any obscure border. It appeared isolated and entirely independent of the equatorial belt, from which it was separated by a brilliant white band. In shade, its color was quite different from the pale rose-color of the equatorial belt, and from every other object which the observer had ever seen on Jupiter, and might be described as a blending of vermilion and blue. Fig. 1 is a copy of the original sketch made immediately after the observation, *a a* indicating the red spot. After this observation, the return of the spot was noticed, and it was drawn fifteen times. It was last seen on December 30, 1878, after which further observations were prevented by the proximity of the sun. The form of the spot changed somewhat during this time: at first, it was long and narrow (Fig. 1, *a a*) ; finally (Fig. 2, *b b*), it became shorter, considerably wider, and extended farther toward the south.—Editor.]

THE SCIENTIFIC ASPECT OF "FREE-WILL."

By ALBERT J. LEFFINGWELL, M. D.

FROM the time when, as Milton tells us, the lost angels

> ". . . . Reasoned high
> Of providence, foreknowledge, will and fate—
> Fixed fate, free-will, foreknowledge absolute "—

no problem has excited greater interest in the human mind than the question of free-will. Philosophy, whether pagan or Christian, atheistic, Catholic, or Protestant, has alike found in its consideration an irresistible attraction ; and, if the world remains to-day of divided opinions, it is not for lack of abundant argument. Seneca taught that "the same necessity binds both gods and men ; divine as well as human affairs proceed onward in an irresistible stream" ; while Pope thought he had solved the problem by imagining a Deity

> "Who, binding Nature fast in fate,
> Left free the human will "—

a flattering conclusion which the world finds it easy to accept. Theology, fearful, on the one hand, of rendering Deity the cause of evil, and, on the other, of limiting his due share in the government of the universe, usually teaches that necessity and free-will are alike true, though not to be reconciled ; a conclusion which would render all reasoning on the subject inconsequential if not absurd. Some have thought to retain their favorite theory by so defining it that no difference of opinion can exist ; as Dr. Haven, for instance, who, in his text-book on "Mental Philosophy," postulates that "freedom of will is power to do *as I like*," and that "the will is free when I can will to do just *what I please*"—seemingly unconscious that the whole question is *why* "I like" or why "I please." Others make both free-will and necessity utterly unfathomable mysteries, and then choose between them. Sir William Hamilton, while admitting that freedom of the will is "wholly incomprehensible"; that we "can not conceive a free volition"; that we are "utterly unable speculatively to understand how moral liberty is possible to man or God"—insists, nevertheless, that the doctrine of necessity is equally unthinkable, because we can not conceive an infinite regression of causes to all eternity; and then finds in "our consciousness of an uncompromising law of duty" a decisive proof of free-will. This is certainly to claim for consciousness of duty, as a witness, a superior function to that which it fills as an agent; for if it has proved again and again an unreliable guide to conduct—leading Calvin to burn Servetus, the Inquisition to torture heretics, and the Puritans to hang witches and Quakers—it is not easy to see why so imperfect a guide to action should be of such supreme value as a testimony to freedom of action. Nor is it clear how a Christian philosopher should have found in our consciousness of the moral law an evidence for a "wholly incomprehensible" theory, superior in force to that which the theistic hypothesis supplies to the doctrine of universal causation.

As it stands to-day, the question is very nearly one between science and theology. On the one hand, science asserts that to the law of causation there are no known exceptions; that mind as well as matter is subject to law. Theology, on the contrary, clings to the freedom of volition as the apparent foundation of morality; and insists that each man is a new cause—a new, unconditioned, responsible factor in the conduct of the universe; and this is the view most generally accepted by the world. The reason is not far to seek: it lies in the teaching of theology regarding man's future state. We instinctively feel that, if upon the nature of our actions depends the awful fate of unending happiness or misery in another existence, justice to the creature demands that his liberty be undetermined in any way by the Creator. Now, theology for the past eighteen centuries has taught, as it yet teaches, this doctrine of eternal punishment. While at the present day it is rarely pushed forward into the old-time prominence, it stands in the creed of every orthodox church; it is yet an essential element of Christian faith. Let us look at it for a moment as presented by a theologian, the greatest that America ever produced, the Rev. Jonathan Edwards. The extracts quoted are from the edition of his sermons published in 1879:

You have often seen a spider when thrown into the midst of a fierce fire; and have observed how immediately it yields to the force of the flames, and the fire takes possession of it, and at once it becomes full of fire, and is burned into a bright coal. Here is a little image of what you will be in hell, except you repent and fly to Christ.—Sermon X.

Do but consider what it is to suffer extreme torment for ever and ever; to suffer it night and day, from one day to another, from one year to another, from one age to another; in pain, in wailing and lamenting, groaning and shrieking and gnashing your teeth; with your bodies and every member full of racking torture; without any possibility of getting ease; without any possibility of moving God to pity by your cries (*sic*). How dismal will it be under these racking torments to know that you never, never shall be delivered from them; to have no hope; when after you have worn out the age of the sun, moon, and stars, without any rest day or night, or one minute's ease, yet you shall have no hope of ever being delivered; you shall know you are not one whit nearer the end of your torments; but the same groans, the same shrieks, the same doleful cries are incessantly to be made by you, and the smoke of your torment shall ascend up for ever and ever; your bodies, which have been burning and roasting all the while in glowing furnaces, yet shall not have been consumed, *but will remain to roast through an eternity yet.*—Sermon XI.

I shall mention several *good* and *important* ends which will be obtained by the eternal punishment of the wicked . . . .

III. The saints will be made more sensible how great their salvation is. When they shall see how great the misery is from which God has saved them, and how great the difference he hath made between their state and the state of others who were by nature, *and perhaps by practice, no more sinful and ill-deserving than they*, it will give them a sense of the wonderfulness of God's grace. . . . The view of the misery of the damned will double the ardor of the love and gratitude of the saints in heaven.

IV. The sight of hell-torments will excite the happiness of the saints for ever: it will make them more sensible of their own happiness; it will give them a more lively relish of it! Oh, it will make them sensible how happy they are!—Sermon XI.

When they shall see how miserable others of their fellow creatures are—when they shall see the smoke of their torment and the raging flames of their burning, and shall hear their shrieks and cries, and consider that they in the mean time are in the most blissful state, and shall surely be in it to all eternity, how they will rejoice! . . . How joyfully they will sing to God and the Lamb when they behold this!—Sermon XIII.

So long as this remains the orthodox view of the fate reserved for a majority of the human race, so long as to doubt the reality of such a Deity is to incur the suspicion of atheism, it will be difficult for men to yield the intellectual figment of "free-will" for the logic of necessity. True, the doctrine of predestination, which teaches that "by the decree of God, and for the manifestation of his glory, some men and angels are predestined unto everlasting life, and others fore-ordained to everlasting death," still stands in many a creed; but most men do not suspect its existence; it is rarely if ever preached at the present day. Otherwise unable to reconcile eternal torture with an ideal of divine justice, probably the faith of ninety-nine out of every hundred persons is that each human being possesses a perfect liberty of choice, and undetermined volition.

The view of science upon this question is widely different. Of eternal fires, which serve at once to torture the skeptic and heighten the felicity of the saint, it knows nothing; the belief in them belongs rather to those cherished mysteries of faith which lie far beyond its scope. In that functional activity we call mind, it recognizes no power to originate uncaused volition. The universe is subject to law. Nothing ever happens or comes to pass without a cause. The cause determines the event, so that it could not be otherwise. What determines volition? Motives. The will is always determined by the strongest motive.

Given the motives which are present to an individual's mind, and given likewise the character and disposition of the individual, his actions might unerringly be inferred.—John Stuart Mill.

The conjunction between motives and voluntary actions is as regular and uniform as that between the cause and effect in any part of Nature.—Hume.

The only meaning of the law of causation in the physical world is, that it generalizes universal experience of the order of that world; and, if experience shows a similar order to obtain among states of consciousness, the law of causation will properly express that order. That such an order exists is acknowledged by every sane man.—Huxley.

It is claimed, however, that consciousness asserts itself with decisive force in favor of free-will. Is this true? "I dispute altogether," says Mill, "that we are conscious of being able to act in opposition to the strongest desire or aversion." But this is a point which we are all able to investigate for ourselves. Indeed, the peculiar advantage of metaphysical study is the opportunity universally possessed of testing theory by observation, in watching the operations of our own minds. I propose, therefore, to go directly upon the ground assumed as their own by the advocates of free-will, and rest the proof of causation upon the uniform testimony of consciousness. It seems to me that the evidence in favor of the scientific view is so cumulative and convincing that a reasonable being, capable of comprehending the problem, and unbiased by dogma, could, after its consideration, more easily assert his intangibility than his liberty of volition.

If we define the will as that "by which the mind chooses anything," and an act of the will as an act of choosing or choice between two or more courses of conduct, or between action and inaction, it is evident that by far the greater portion of our acts occur without conscious exercise of this faculty. Walking along a muddy street, engaged in deep thought or earnest conversation with a friend, one picks his way, but consciously does not determine where at each step his foot is to be placed. We laugh when amused; weep from sympathy or grief; cry from pain; become agitated, irritable, excited, or angry, if sufficiently vexed, without previous choice whether or not we shall yield to these emotions. We speak of ourselves as acting "from the impulse of the moment," from habit, or "as we always do under such circumstances." Let any one, for instance, review in his mind the events of yesterday, from the first moment of awakened consciousness until he sank into slumber at night, and remember, if he can, before how many of the ten thousand actions which constituted his daily life he paused to choose. Awakened in the morning, he arose, doubtless, at his usual hour—performed ablution, assumed his garments, one by one, in a certain methodical order, and descended to breakfast. He read portions of his newspaper ; commented on events or politics ; the coffee was burned and the steak tough, and he was irritable and morose ; or both were excellent, and he was amiable and talkative. He walked to his place of business by the route he always takes ; crossing the streets where he had crossed a thousand times previously ; arriving at the usual hour, notwithstanding he might have made—had the motives existed—innumerable variations from his regular course in each of these proceedings. Now, up to this point, he has probably performed several thousand distinct muscular efforts, each under the control of his will—from the glance of an eye to the propulsion of his body along the street. How many of them can he remember, or does he suppose to have resulted from conscious choice between action as performed and another imaginable possible alternative ? Probably he could count on his fingers all the acts of conscious choice performed during the entire day. The rest have been as instinctive and impulsive, as unconsciously determined by circumstances, as the operations of ordinary animal existence.

Turning now to the consideration of those acts which are preceded by that conscious weighing of motives which constitutes true volition, we shall find these no less determined by law. Appealing confidently to the consciousness of every reader, I submit that *we not only invariably choose, but we* CAN ONLY CHOOSE, *that object or course of action which at the instant, the will is exercised to choose, appears to us, all things considered, the most desirable.*

This can hardly be doubted. For the very act of conscious choice implies of necessity (except in those imaginary cases of absolute indifference wherein morality can not be concerned) *a preference*, even if it be only momentary. Mind, I do not say the thing chosen is really desirable ; perhaps the only courses open are all very undesirable, terrible, full of painful consequences, and the confused mind may pass from one to another with a hesitating tremulousness of indecision—obliged, however, ultimately to make a choice. Put yourself to any fair test, and see if you can possibly choose that which you prefer least to choose. Pain is exceedingly undesirable, is it not ? Take a needle and place the point against your bared arm ; now choose whether or not you shall force it to enter your flesh. "But it will hurt me," you say, and you throw down the needle, proceeding no further. Do you so decide *without cause ?* Or perhaps you push the point beneath the skin, and inflict upon yourself pain, without apparent adequate motive.

Yet is it not evident that the mere desire to make the experiment made even the pain momentarily desirable? But, omitting the petty experiences of our every-day life, let us test the proposition by reference to the highest occasions of choice possible to man. Life is sweet, and yet how poor would be the records of heroism did they not tell us of men who, for the sake of great and noble ends, preferred death! You can not imagine them as choosing it if they did not regard it as the more desirable. We have all seen the picture of the Huguenot lovers, on the eve of St. Bartholomew, and the choice of death which one made even in the arms of her he loved. How many martyrs in silent dungeons have been offered life, liberty, home, and the loving companionship of wife and children, the possibility of long years of happiness and usefulness, at the price of apostasy to their convictions; who chose rather an ignominious death at the stake, prolonged tortures, confiscation of property, beggary of children, execration of friends, a dishonored and forgotten name—and whose faces shone with happiness as the flames kindled around them! But men have chosen more than this—not only to die, but to live a life of torture first. History does not record for us instances of greater self-abnegation, of more intense eagerness to suffer and to die for others, than those of the Jesuit missionaries who labored among the Indians of this country two centuries ago. One of them, writing from the Iroquois country in 1644, said: "This letter is soiled and ill-written, because the writer has only one finger of his right hand left entire, and can not prevent the blood oozing from his wounds, still open, from staining the paper." He had suffered protracted tortures in every form consistent with the preservation of life: given to children to torment; burned with live coals, forced to walk on hot cinders, hung by the feet, lacerated by savage dogs; a finger-nail burned off one day, and the joint burned off the next—a fiendish economy of torture—and finally ransomed by the Dutch, only to save him from the stake; yet, as soon as his health was partially restored, he chose to embark again for the wilderness and its awful possibilities. Turn the yellow pages of the missionary "Relations" and you come upon sentiments like these, expressed in the antiquated orthography of the time: "Nous mourrons, nous serons pris, nous serons bruslez, nous serons massacrez—passe. Je ne voy icy personne baisser la tête; au contraire—on demande de monter aux Hurons; et quelques uns protestent *que les feux des Hiroquois sont l'un de leur motifs pour entreprendre un voyage si dangereux!*" Of others, their biographer says: "They had borne all that the human frame seems capable of bearing. They had escaped as by miracle from torture and death. Did their zeal flag or their courage fail? A fervor, intense and unquenchable, urged them on to more distant and more deadly ventures. They burned to do, to suffer, to die; and now from out a living martyrdom they turned their heroic gaze toward a horizon dark with perils yet more appalling, and saw in hope the day when they might bear the cross into the blood-stained dens of the Iroquois." In the tortured captives they had baptized even amid the flames, they saw their own fate, but it caused not a moment's hesitation. These all chose *what to them semed most desirable*; for, beyond torture and death, they seemed to see the martyr's crown, the eternal reward. Not less on these supreme occasions than in the most ordinary affairs of daily life, *choice is determined by the apparent desirableness of things.*

But, if this be granted, it immediately becomes evident that one's views of what is desirable arise from an infinite variety of coincident circumstances with which the individual concerned had no more to do than with the shape of his skull or the color of his skin. That no two persons have exactly the same preferences or tastes, or would choose alike on every occasion, is a truism. Their ideas of what is desirable may have resulted from congenital or inherited constitutional tendencies. A drunkard's children are often endowed with a craving for stimulants, that sooner or later brings them to drunkards' graves. One man possesses fierce and strong animal propensities; another is never tempted by vicious allurements. The social condition of men has a great influence in this respect. I do not suppose the Prince of Wales ever perceived the desirableness of snatching a loaf from a baker's cart; but many a starving London tramp has felt it. Hunger and poverty meet a thousand temptations that never assail full stomachs and well-clothed bodies. Victor Hugo says that English statistics prove four robberies out of five to have hunger for their immediate cause. Or the state of the health may influence men's views of the desirableness of things. Of the effect of impaired vitality in vitiating desires, every physician is aware. Many of us, offered a glass of wine, could accept it without the remotest danger of thereby becoming drunkards; but others, men like Mr. Gough, tell us that for them such indulgence would be the first step to a long debauch. How powerful is the influence of habit in this respect! I enter a tobacconist's with no other desire apparent to myself than to do my errand and escape as soon as possible; but a venerable gentleman told me the other day that, after breaking off the use of tobacco for thirteen years, the chance inspection of some fresh samples renewed with overwhelming force the old appetite and refixed the old habit. Or the decision may be due to occasion and other surrounding circumstances attending the moment of choice. There is a profound significance in the petition, "Lead us not into temptation." Many a woman walks our streets wrecked, from the fortuitous conjunction of opportunity, temptation, and desire, whose virtue would never have yielded to either alone. What an immense influence is exerted upon men's desires by their religious belief! The Jesuit among the Hurons could choose a daily martyrdom that, now and then, he might touch a dying papoose with holy water and snatch its little soul from eternal fires;

can we imagine a Universalist clergyman so suffering for such results? How largely also are our notions of right and wrong determined for us by early parental training! A landlady of mine, in Leipsic, a pastor's daughter, of the most rigid type of Protestant orthodoxy, attended church one Sunday morning, and a representation of "Faust" at the theatre the same evening; and saw no incongruity in a course which, by a majority of people in this country, would be regarded as a fearful sin. Both views of Sunday are merely results of religious education at a period when the mind is peculiarly receptive, and when no one claims that a child should decide as to the correctness of the opinions taught. These are only a few out of the infinite number of circumstances, beyond individual control, which decide what shall be the views we take of the qualities of things and the desirableness of action. They mold character; they shape opinions; they make the man what he is. Since by these facts of organization, education, religious training, social position, etc., independent of our wish or will, are determined for us the views we invariably take of the apparent desirableness of all objects or actions—since upon this apparent desirableness the choice of conduct of mankind invariably depends—it follows that the human will is as subject to the law of causation as the movements of the planets or the flight of an insect in the air.

It is asserted, however, by the advocates of the popular doctrine, that the scientific negation of free-will obliterates what is called "moral responsibility," and places man, as respects his actions, on the plane of other animals. A full consideration of this point would lead us too far aside from our subject; yet, were all imagined consequences sure to arise from general disbelief in accountability for action, I fail to see how this proves the truth of the doctrine of free-will. It can never be too often repeated that, regarding each and every theory, dogma, or proposition, Science can ask but one question, *Is it true?* The answer must come from other sources than the imagined sequence of its acceptance or rejection. But let us suppose that mankind should some day admit the proposition that moral responsibility, in the theological sense, does not exist; that the will is determined by the strongest motive: what fearful results would ensue! Would punishment cease to follow crime? On the contrary, its use would never be more logical. If the stronger motive has led an individual to transgress the rights of society, then society must punish for three reasons: 1. That the memory of the punishment may act as a strong motive in deterring from future repetition of the offense; 2. That the example may deter others; and, 3. That society may be protected from a dangerous man. These reasons are all consistent with the doctrine of necessity; what others would the advocates of uncaused volition add? To assert that punishment should only be inflicted where "moral responsibility" exists, is either to confer it upon our domestic animals, or else to deny the justice of our every-day action regarding them. A child throws stones at strangers passing by; a dog barks at their heels; both are soundly whipped at each offense, and sooner or later both cease its repetition. In both instances punishment was given from the same standpoint; its action on child and dog was alike—equally effectual, and I see no reason for the interposition of moral responsibility in the one case, if denied in the other.

I do not believe that the doctrine of necessity, if generally held, would lessen in any way our abhorrence of evil, or our approval of the good. To assert, as Professor Bascom does in his recent work on "Ethics," as a proof of free-will, that the doctrine of necessity "does not merely strangle virtue—it leaves every thought and action as true and as just, one as another," and that "all our moral action loses its character without liberty," seems to me to make statements unsupported by any evidence whatever. Would Professor Bascom allow that Deity is free to become a fiend? And if not—if to be God he must *of necessity* be good—does he conceive that divine action "loses its character without liberty"? Or can he explain why conduct should be deprived of the distinctions of good and evil because conditioned, any more than physical qualities admitted to be determined independently of the individual's will? If beauty in the human form is better than ugliness, health than disease, symmetry than distortion, intelligence than idiocy, why should not modesty, humanity, justice, and truth, not only seem, but *be* better than profligacy, cruelty, iniquity, and falsehood? The fact is, goodness is essentially beautiful, and in the slow progress of mankind upward, from savagery to the ultimate civilization yet to be, can not fail to command admiration. Evil is hateful, independently of its relations to ethics, and its awful realm extends far beyond the area of human action. In the spider springing upon the entangled fly, the cat playing with its victim before tearing it to pieces, in the teeth of the shark, the fangs of the rattlesnake, the poisonous slaver of the rabid dog; in the deposition of tubercle, the slow growth of cancer, the ravages of syphilis upon innocent childhood, we get glimpses of the great mystery of Evil, separate from human will, where we pity but never condemn. And if, perchance, some day the world should learn to discriminate in the sphere of human action between the deed and doer; if, acknowledging necessity, it should come to have a larger and more comprehensive charity for all mankind, will it have strayed very far from the example and precepts of the world's great Teacher? Was there not one who, hating leprosy, loved the leper?—about whom Pharisees murmured because he sat at meat with sinners?—who condemned not her whom the law would have stoned?—who taught that "it must needs be that offenses come," and whose last prayer asked forgiveness for his enemies, "for they know not what they do"? I do not believe these dying words were without meaning; they were the expression of a scientific truth.

Nor, finally, will belief in the conformity of will to law hinder our approval and admiration of great and good deeds. The highest and noblest action results never from conscious choice, but springs unconsciously from the force of noble character—"instinctively," as we sometimes say. Of Cato, it was said that he was good because he could not be otherwise. So far from lessening the excellence of conduct that noble motives act always with irresistible force upon great men, that is the chief reason for honoring them, because they at least could not act ignobly. "Here I stand," said Luther, at Worms, "God help me, Ich kann nicht anders!" This is the key-note of noble action everywhere, "I can not otherwise!" The engineer, at New Hamburgh, hesitating not a moment when duty called him to a horrible death; the captain of the sinking steamer who will not leave the ship until every passenger is safe, and so goes down with her; Arnold Winkelried crying, "Make way for liberty!" and rushing upon the Austrian spears; Sir Philip Sidney, mortally wounded, taking from his parched lips the water brought him, that a poor soldier, who looked longingly with dying eyes at the cup, might first drink; the martyrs who have chosen to suffer ignominy and death that we might have freedom of thought and speech—these are types of men humanity will ever honor; their example and memory we shall reverence even though we know—rather *because* we know—that the needle points not more surely to the pole than that for them, there and then, meanness was impossible—that their great souls were only capable of noble deeds.

EXPERIMENTAL LEGISLATION.

By Professor W. STANLEY JEVONS.

"A FOOL, Mr. Edgeworth, is one who has never made an experiment." Such are, I believe, the exact words of the remark which Erasmus Darwin addressed to Richard Lovell Edgeworth. They deserve to become proverbial. They have the broad foundation of truth and the trenchant disregard of accuracy in detail which mark an adage. Of course, the saying at once suggests the question, What is an experiment? In a certain way, all people, whether fools or wise men, are constantly making experiments. The education of the infant is thoroughly experimental from the very first, only in a hap-hazard and unconscious way. The child which overbalances itself in learning to walk is experimenting on the law of gravity. All successful action is successful experiment, in the broadest sense of the term, and every mistake or failure is a negative experiment, which deters us from repetition. Our mental framework, too, is marvelously contrived, so as to go on ceaselessly registering on the tablets of the memory the favorable or unfavorable results of every kind of action. Charles Babbage proposed to make an automaton chess-player which should register mechanically the number of games lost and gained in consequence of every sort of move. Thus, the longer the automaton went on playing games, the more experienced it would become by the accumulation of experimental results. Such a machine precisely represents the acquirement of experience by our nervous organization.

But Erasmus Darwin doubtless meant by experiment something more than this unintentional heaping-up of experience. The part of wisdom is to learn to foresee the results of our actions, by making slight and harmless trials before we commit ourselves to an irrevocable line of conduct. We ought to feel our way, and try the ice before we venture on it to a dangerous extent. To make an experiment, in this more proper sense, is to arrange certain known conditions, or, in other words, to put together certain causal agents, in order to ascertain their aggregate outcome or effect. The experiment has knowledge alone for its immediate purpose. But he is truly happy, as the Latin poet said, who can discern the causes of things, for, these being known, we can proceed at once to safe and profitable applications.

It need hardly be said that it is to frequent and carefully planned appeals to experiment in the physical sciences that we owe almost all the progress of the human race in the last three centuries. Even moral and intellectual triumphs might often be traced back to dependence on physical inventions, and to the incentive which they give to general activity. Certainly, political and military success is almost entirely dependent on the experimental sciences. It is difficult to discover that, as regards courage, our soldiers in Afghanistan and Zooloo-land are any better than the men whose countries they invade. But it is the science of the rifle, the shell, and the mountain-gun—science perfected by constant experimentation—which gives the poor savage no chance of successful resistance. To whom do we owe all this in its first beginning, but to the great experimentalist, the friar, Roger Bacon, of Oxford, our truest and greatest national glory, the smallest of whose merits is that he first mentions gunpowder; yet so little does this nation yet appreciate the sources of its power and greatness that the writings of Roger Bacon lie, to a great extent, unprinted and unexplored. It is only among Continental scholars that Roger Bacon is regarded as the miracle of his age and country.

No doubt it is to Francis Bacon, the Lord High Chancellor of England, that the world generally attributes the inauguration of the new inductive era of science. This is hardly the place to endeavor to decide whether the world has not made a great mistake. Professor Fowler, in his admirable critical edition of the "Novum Organum," has said about all that can be said in favor of Lord Bacon's scientific claims; yet I hold to the opinion, long since stoutly maintained by the late Professor De Morgan, not to speak of Baron Liebig and others, that Lord Bacon, though a truly clever man, was a mere dabbler in inductive science, the true methods of which he quite misapprehended. At best, he put into elegant and striking language an estimate of the tendency of science toward experimentalism, and a forecast of the results to be obtained. The regeneration of these last centuries is due to a long series of philosophers, from Copernicus, Galileo, Descartes, Newton, Leibnitz, down to Watt, Faraday, and Joule. Such men followed a procedure very different from that of Francis Bacon.

Now we come to the point of our inquiry. Is the experimental method necessarily restricted to the world of physical science? Do we sufficiently apply to moral, social, and political matters those methods which have been proved so invaluable in the hands of physical philosophers? Do our legislators, in short, appeal to experiment in a way which excepts them from the definition of Erasmus Darwin? English legislation, no doubt, is usually preceded by a great amount of public discussion and Parliamentary wrangling. Sometimes there is plenty of statistical inquiry—plenty, that is, if it were of the right sort and conducted according to true scientific method. Nevertheless, I venture to maintain that as a general rule Parliament ignores the one true way of appealing directly to experience. Our Parliamentary Committees and Royal Commissions of Inquiry pile up Blue-books full of information which is generally not to the point. The one bit of information, the actual trial of a new measure on a small scale, is not forthcoming, because Parliament, if it enacts a law at all, enacts it for the whole kingdom. It habitually makes a leap in the dark, because I suppose it is not consistent with the wisdom and dignity of Parliament to grope its way, and feel for a safe footing. Now, I maintain that, in large classes of legislative affairs, there is really nothing to prevent our making direct experiments upon the living social organism. Not only is social experimentation a possible thing, but it is in every part of the kingdom, excepting the palace of St. Stephen's, the commonest thing possible, the universal mode of social progress. It would hardly be too much to say that social progress is social experimentation, and social experimentation is social progress. Changes effected by any important act of Parliament are like storms, earthquakes, and cataclysms, which disturb the continuous course of social growth. Sometimes they do much good; sometimes much harm; but in any case it is hardly possible to forecast the result of a considerable catastrophic change in the social organism. Therefore I hold unhesitatingly that, whenever it is possible, legislation should observe the order of nature and proceed tentatively.

Social progress, I have said, is social experimentation. Every new heading that is inserted in the London Trades' Directory is claimed by those private individuals who have tried a new trade and found it to answer. The struggle for existence makes us all look out for chances of profit. We are all perhaps in some degree inventors, but some are more bold and successful. Now, every man who establishes a shop or factory or social institution of a novel kind is trying an experiment. If he hits an unsupplied need of his fellow men, the experiment *succeeds;* that is, it has something succeeding or following it, namely, repetition by himself and others. The word "success" is a most happy one etymologically. To have success is to have a future —a future of imitators.

It is quite apparent that all the great novelties of recent times have been worked out in this tentative way. How, for instance, has our vast and marvelous railway system been developed? Did it spring forth perfect from the wise forethought of Parliament, as Minerva, fully armed and equipped, leaped from the head of Jupiter? On the contrary, did not our wise land-owners and practical men oppose railways to the very utmost—until they discovered what a mistake they were making? There is no great blame to them. Who, indeed, could see in the rude tram-line of Benjamin Outram the germ which was to grow into the maze of lines, and points, and signals which we now pass through without surprise at Clapham Junction or at London Bridge? That most complex organization, a great railway station, is entirely a product of frequent experiment. *Gradutim*—step by step —would be no unapt motto for any great industrial successes. In such matters experiments are both intentional and unintentional. Of the former the public hears little, except when they result in some profitable patent. The preliminary trials are usually performed in secret, for obvious reasons, and the unsuccessful ones are left undescribed and are quickly forgotten. As to unintentional experiments, they are too numerous. Every railway accident which happens is an experiment revealing some fault of design, some insufficiency in the materials, some contingency unprovided for. The accident is inquired into, and then the engineers set to work to plan improvements which shall prevent the like accident from happening in the future. If we had time to trace the history of the steam-engine, of gas-lighting, of electric telegraphs, of submarine cables, of electric lighting, or of any other great improvement, we should see, in like manner, that the wisdom of Parliament has had nothing to do with planning it. From the first to the last the rule of progress has been that of the ancient nursery rhyme—"Try, try, try: And if at first you don't succeed, Try, try, again."

To put the matter in the strongest light, let the reader consider what he would say about a proposal that Parliament should decide arbitrarily, by its own wisdom, concerning any great impending improvement; take, for instance, that of tramways and steam tram-cars. It is quite conceivable that steam tram-cars will eventually succeed so well as to replace horse conveyance to a great extent. All main highways will then, of course, be laid with tram-rails. But what should we think of the wisdom of Parliament if it undertook to settle the question once for all, and, after taking a score of Blue-books full of evidence, to decide either that there should be no steam tram-cars, or that steam tramways should be immediately laid down between all the villages in the kingdom? The House of Lords did take the former course two sessions ago, and prohibited the use of steam on tramways, because it might frighten horses. In the next session they felt the folly of opposing the irresistible, and expressly allowed the *experimental use* of steam on tramways.

It may, perhaps, be objected that these are matters of physical science and practical engineering, in which the supremacy of experiment has long been recognized. That is not wholly so; for the success of a system, like that of the railways or tramways, depends much upon social considerations. However that may be, there is no difficulty in showing that the same principles apply to the most purely social institutions. If anything, it is the social side of an enterprise which is usually most doubtful, and most in need of experiment when it can be applied. To construct the Thames Tunnel was a novel and difficult work at the time, but not so difficult as to get the populace to use it. The Great Eastern steamship was another instance of a great mechanical success, which was a social and economical failure. Many like cases might be mentioned, such as the real-ice rinks lately invented.

How is it that any kind of purely social institution is usually established? Take the case of the Volunteer Force. This was commenced, not to speak of earlier movements, or the ancient Honorable Artillery Company, by a few isolated experiments, such as that of the Exeter Rifle Corps in 1852, and the Victoria Rifle Corps in 1853. These succeeded so well that, when in 1859 fears of invasion were afloat, the imitative process set in rapidly. Of course wise, practical people laughed at the mania for playing at soldiers, and most people clearly foresaw that, when once the volunteers had got tired of their new uniforms, the whole thing would collapse. But experience has decided very differently. The force, instead of declining, has gone on steadily growing and substantially improving, until a good authority lately spoke of it as the only sound part of our military system. How much has the wisdom of Parliament had to do with the creation of this force? I believe that even now the Government and the military classes do not appreciate what the volunteer force has done for us by removing all fear of safety at home and enabling the standing army to be freely sent abroad.

Take, again, the case of popular amusements. Would Parliament ever think of defining by act of Parliament when and how people shall meet to amuse themselves, and what they shall do, and when they shall have had enough of it? Must not people find out by trial what pleases and what does not? The late Mr. Sergeant Cox is said to have invented penny readings for the people, and they answered so well under his management that they were imitated in all parts of the kingdom, and eventually in many other parts of the world. Spelling-bees were, I believe, an American invention, and had a very lively but brief career. The recent courses of popular scientific lectures arose out of the very successful experiment instituted by Professor Roscoe at Manchester. Many attempts are just now being made to provide attractive and harmless amusements for the people, and this must, of course, be done in a tentative manner.

It is curious, indeed, to observe how evanescent many social inventions prove themselves to be; growth and change have been so rapid of late that there is constant need of new inventions. The Royal Institution in Albemarle Street was a notable invention of its time, chiefly due to Count Rumford, and its brilliant success led to early imitation in Liverpool, Manchester, Edinburgh, and perhaps elsewhere. But the provincial institutions have with difficulty maintained their *raison d'être*. After the Royal Institutions came a series of Mechanics' Institutions, which, as regards the mechanics element, were thoroughly unsuccessful, but proved themselves useful in the form of popular colleges or middle-class schools. Now, the great and genuine success of Owens College, as a teaching body, is leading to the creation of numerous local colleges of similar type. This is the age, again, of free public libraries, the practicability and extreme usefulness of which were first established in Manchester. When once possessed of local habitations, such institutions will, it may be hoped, have long careers; but bricks and mortar are usually requisite to give perpetuity to a social experiment. When thus perpetuated, each kind of institution marks its own age with almost geologic certainty. From the times of the Saxons and the Normans we can trace a series of strata of institutions superposed in order of time—the ancient Colleges of Oxford and Cambridge, the mediæval guilds surviving in the city companies, the grammar-schools of the Elizabethan age, the almshouses of the Stuart period, the commercial institutions of Queen Anne's reign, and so on down to the free libraries and recreation palaces of the present day. Even styles of architecture are evolved by successful innovation, that is, experiment followed by imitation, and this was never more apparent than in the imitation which has followed upon Sir Joseph Paxton's grand experiment at the Exhibition of 1851.*

Now, my contention is that legislators ought, in many branches of legislation, to adopt confessedly this tentative procedure, which is the very method of social growth. Parliament must give up the pretension that it can enact the creation of certain social institutions to be carried on as specified in the "hereinafter contained" clauses. No

* I do not remember to have seen the importance of this imitative tendency in social affairs described by any writer, except the French engineer and economist Dupuit, who fully describes it in one of his remarkable memoirs, printed in the "Annales des Ponts et Chaussées."

doubt, by aid of an elaborate machinery of administration and a powerful body of police, Government can, to a certain extent, guide, or at any rate restrain, the conduct of its subjects. Even in this respect its powers are very limited, and a law which does not command the consent of the body of the people must soon be repealed or become inoperative. But, as regards the creation of institutions, Parliament is almost powerless, except by consulting the needs of the time, and offering facilities for such institutions to grow up as experience shows to be successful. But an unfortunate confusion of ideas exists, and it seems to be supposed that, because for reasons of obvious convenience the civil and criminal laws are as a general rule made uniform for the whole kingdom, therefore the legislative action of Parliament must always be uniform and definitive. When an important change is advocated, for instance, in the licensing laws, Parliament collects abundant information, which is usually inconclusive, and then proceeds to effect all over the kingdom some very costly and irrevocable change—a change which generally disappoints its own advocates. Take the case of the Sale of Beer Act of 1830, generally known as the Beershop Act. This is a salient example of bad legislation. Yet it was passed by the almost unanimous wisdom of Parliament, the division in the House of Commons on the second reading showing two hundred and forty-five ayes and only twenty-nine noes. The act originated with Brougham, in the sense that he had in 1822 and 1823 brought in somewhat similar bills, which were partially adopted by the Government of 1830. The idea of the act was to break down the monopoly of the brewers and publicans; to throw open the trade in beer on free-trade principles; and, by offering abundance of wholesome, pure, weak beer, to draw away the working classes from the gin-shops. All seemed as plausible as it was undoubtedly well intended. Objections were of course made to the bill, and many people predicted evil consequences; but all such sinister predictions were supposed to be spread about by the interested publicans and brewers. Nevertheless, the new act was soon believed to be a mistake. Sydney Smith, though he had not many years before pleaded for liberty for the people to drink rum-and-water, or whatever else they liked ("Edinburgh Review," 1819), quickly veered round, and gave a graphic account of the beastly state of drunkenness of the sovereign people.

It may be safely said that the Beershop Act realized all the evils expected from it, and few or none of the advantages. It is difficult to say anything in favor of the bar at the corner public-house, except that it is better than the dirty low little beershop, hiding itself away in some obscure recess of the streets. The first is at any rate under the gaze of the public and the control of the magistrates; the beershop, until within the last few years, was too likely to become the uncontrolled resort of the worst classes. Even now that the beershops are brought under the Licensing Magistrates, many years must elapse before the evil wrought by the act of 1830 can be thoroughly removed. This, then, is a striking instance of a leap in the dark, which ought never to have been committed by a prudent Legislature. When the Sale of Beer Bill was under discussion, the Chancellor of the Exchequer seemed to feel that it was a bill which needed experimental trial; for, when objection was made that the act would not extend to Scotland, he urged that it might be better to try the act in one part of the kingdom in the first instance, and then, if it were found to be beneficial, and to answer its intended objects, it might be extended to other parts.*

In more recent years the granting of grocers' licenses for the free sale of all kinds of spirituous liquors is likely to prove itself to be an equally disastrous leap in the dark. With the very best intentions, and on the most plausible theoretical grounds, Mr. Gladstone's Government greatly extended the free sale of wine and beer, so that now, in some popular watering-places, I have noticed that almost every third shop-window is ornamented with a pyramid of beer-bottles. Yet the late Government have only succeeded in making the grocers' shop the avenue to the publican's bar. No one can for a moment believe that the free sale of liquors for home use has in the least degree weakened the publican's hold on his customers. If I had on *a priori* grounds to plan out a scheme of liquor-traffic, I should just reverse the existing law relating to beershops and grocers' licenses. I would prohibit the "off" sale of liquor on any premises where other articles were sold; the purchaser desiring to buy wine, beer, or spirits for home use should be obliged to go to some one of a comparatively few well-marked shops dealing in those things alone. On the other hand, where liquor is sold for consumption on the premises, I should oblige the seller to furnish food and reasonable sitting accommodation. This would be nothing more than a return to the old law about licensed victualers, which yet exists in the letter, though it has been allowed to fall into practical abeyance. The very reasonable law obliging publicans to afford general entertainment was sadly broken down by the Beershops Act, which provided unlimited means for the drinking of beer, pure and simple, without food of any kind. But my contention is, that we must not proceed in such matters on *a priori* grounds at all. We must try.

Perhaps it may be said that every new law is necessarily an experiment, and affords experience for its own improvement, and, if necessary, its abrogation. But there are two strong reasons why an act which has been made general, and has come into general operation, can seldom serve as an experiment. Of course, a great many acts of Parliament are experimentally found to be mistaken, for they never come into considerable operation at all, like the acts to promote registration of titles, not to mention the Agricultural Holdings Act. Such

* "Hansard's Debates," April 8, 1830, New Series, vol. xxiv., p. 26.

cases prove little or nothing, except the weakness, and possibly the insincerity, of the Legislature. But if an act comes largely into operation it is practically irrevocable. Parliament can not say simply "as you were," and proceed to a new and more hopeful experiment. A social humpty-dumpty can not be set up again just as it was before even by the Queen's men. The vested interests created are usually too formidable to be put aside, and too expensive to be bought up. A good many years, say seven, or ten at the least, are needed to develop properly any important legislative experiment, so that the same generation of statesmen would not have more than three or four opportunities of experiment in the same subject during the longest political career. If we divide up the country, and try one experiment on one town or county, and another on another, there is a possibility of making an almost unlimited number of valid trials within ten or twenty years. But, apart from this consideration, a general legislative change is not a true experiment at all, because it affords no clear means of distinguishing its effects from the general resultant of social and industrial progress. Statistical facts are usually numerical or quantitative in character, so that, if many causal agencies are in operation at the same time, their effects are simply added together algebraically, and are inextricably merged into a general total. Thus, the total numbers receiving poor-law relief, or the numbers apprehended in the kingdom for drunkenness, are numerical results affected by the oscillations of trade, by the character of the seasons, the value of gold, etc., etc., as well as by the acts of the Legislature. To make a valid experiment we must have a certain thing subject to certain constant conditions, and we must introduce a single definite change of condition, which will then be probably the cause of whatever phenomenon follows. It is possible, indeed, to experiment upon an object of varying conditions, provided we can find two objects which vary similarly; we then operate upon the one, and observe how it subsequently differs from the other. We need, in fact, what the chemists call a "blind experiment." Suppose, for instance, that an agricultural chemist or a scientific farmer wished to ascertain the effect of a new kind of manure; would it be rational for him to spread the manure over all his available land? Would it not then be doubtful whether the increase or decrease of yield were due to the manure or to the character of the seasons? In this case his neighbors' crops might, to some extent, furnish the blind experiment, showing what had been the ordinary yield. But, of course, the obvious mode of procedure is to spread the new manure over a part only of each experimental field, so that the difference of the crops on the different patches brings out, in the most unquestionable way, the effect of the manure. Not only is the smaller experiment, in a logical point of view, far better than the larger one, but it is possible to try many concurrent small experiments upon a farm of moderate extent.

I maintain that, if our legislators are to act rationally, they will as far as possible imitate the agricultural chemist. The idea, for instance, of obliging, or even allowing, all the boroughs in the kingdom simultaneously to adopt the Gothenburg plan, would be ridiculous and irrational. The cost and confusion which would arise from a sudden general trial must be very great; many years would elapse before the result was apparent. And that result would not be so clear as if the trial were restricted to some half a dozen towns. In the mean time it would be far better that other boroughs should be trying other experiments, giving us many strings to our bow, while some towns would actually do best for the country by going on as nearly as possible in their present course. Specific and differentiated experience is what we need, before making any further important change in the drink-trade.

Not only is this the rational method of procedure, but it is practically the method to which we owe all the more successful legislative and administrative reforms of later years. Consider the Poor Law question. During the eighteenth century, Parliament made two or three leaps in the dark, by enacting laws such as Gilbert's Act, and very nearly ruined the kingdom by them. The great Poor Law Commission commenced its operations in the soundest way by collecting all available information about the treatment of the poor, whether at home or abroad. But, what is more to the point, since the new Poor Law was passed in 1834, the partially free action of Boards of Guardians, under the supervision of the Poor Law Commission and the Poor Law Board, has afforded a long series of experimental results. The reports of Mr. Edwin Chadwick and the late Sir George Shaw Lefevre are probably the best models of the true process of administrative reform to be anywhere found. In more recent years several very important experiments have been tried by different Boards of Guardians, such as the boarding out of pauper children, the suppression of vagrancy by the provision of separate vagrant cells and the hard-labor test, and the cutting down of outdoor relief. If the total abolition of outdoor relief is ever to be tried, it must be tried on the small scale first; it would be a far too severe and dangerous measure to force upon the whole country at a single blow. Much attention has lately been drawn to the so-called "Poor-Law Experiment at Elberfeld," which was carefully described by the Rev. W. Walter Edwards, in an article in the "Contemporary Review" for July, 1878, bearing that precise title.

Even when an act of Parliament is passed in general terms applying to the whole kingdom at once, it by no means follows that it will be equally put into operation everywhere. The discretion necessarily allowed to magistrates and other authorities often gives ample scope for instructive experiments. Some years since the Howard Association called attention to what they expressly called "The Luton Experiment," consisting in the extraordinary success with which the magistrates of Luton in Bedfordshire enforced the provisions of the "Prevention of Crime Act." The number of committals to jail from Luton and its vicinity was reduced from two hundred and fifty-seven in 1869 to sixty-six in 1874. The only fault of the experiment consists in the possibility that the thieves and roughs migrated, but this difficulty would be less serious had the experiment been tried in larger towns.

What little insight we can gain into the operation of the licensing laws is mainly due to the considerable differences with which they have been administered in different places. Such is the latitude of discretion given by the law that magistrates can often make very distinct experiments. A short time ago the magistrates of Glasgow intentionally and avowedly made the experiment of locking up in jail all the drunkards brought before them. When I last heard about this experiment it was on the point of failing, because the jails of Glasgow were all quite full, and still the drunkards were coming to the bar. In 1863 the Licensing Magistrates of Liverpool commenced a most interesting experiment, by declaring their intention to adopt "free licensing," that is, to grant licenses to any suitable persons who applied for them. The publicans' licenses were increased from sixteen hundred and seventy-four in 1862 to nineteen hundred and forty in 1866. The system was abandoned in this last year, owing to a change in the constitution of the Bench. None of the magistrates who advocated the change, we are told, ever recanted, but some who supported the change to a restrictive policy have been disappointed with the results. The teaching of this real experiment has been carefully discussed by Mr. S. G. Rathbone in a very able letter, published in the "Times" of the 12th of February, 1877, as also in his evidence before the Lords' Committee of Inquiry on Intemperance (questions 259–384, etc.). But, apart from his objections to the interpretation put upon the facts, the experiment was not continued sufficiently long, and the town in which it was tried is so unique in the annals of intemperance as to be ill-fitted for the purpose.

Much attention has been drawn recently to the merits of the so-called Gothenburg scheme, the adoption of which has been so ably advocated by Mr. J. Chamberlain, M. P. Now, what is this advocacy but argument from a successful experiment? The municipal authorities of Gothenburg allowed a certain method of conducting the sale of liquor to be tried there, and the success was apparently so great that other Swedish towns are rapidly adopting the same plan. This is just the right procedure of trial and imitation. But, if Mr. Chamberlain means that, because the plan succeeds in Gothenburg, therefore the municipal authorities of English towns ought at once to be obliged to purchase and administer the public-houses, he goes much too far. All we ought to do is to try the system in a limited number of towns. Any one acquainted with the bright little Swedish seaport, and the orderly, polished lower-class population of Sweden, will be in no hurry to draw analogies between their condition and that of our great, busy, turbulent Anglo-Irish towns. At any rate it is obvious that experiments ought to be made upon the most closely proximate cases which can be found, and, if three or four such towns as Birmingham, Bristol, Bolton, and Newcastle-upon-Tyne could be induced to try the Gothenburg scheme, it would be an ample first experiment. Even between English towns the differences of magnitude, race, occupation, and local government are often so great that it is by no means certain that the same scheme will succeed equally in all. The differences in the intemperance rates in the several boroughs of England, to which I shall perhaps draw attention on a future occasion, are so extraordinary and profound that the Committee of the House of Lords were thoroughly bewildered on the subject. Under such circumstances it should not be assumed that uniform legislation must be the ultimate object of our efforts.

It is a most important question how far the proposals of the United Kingdom Alliance for the Suppression of the Liquor Traffic can be approved from the point of view here taken up. I venture to maintain that those proposals, so far as embodied in the Permissive Prohibitory Bill, now dropped, had all the possible evils of a great legislative leap in the dark, with few of the corresponding possible advantages. Four years ago, in a paper read to the Manchester Statistical Society, I gave reasons for believing that the long-continued and costly proceedings of the Alliance were simply thrown away, except so far as they might be a warning against similar unwise attempts at legislation. I showed that the Alliance were striving against triple improbabilities: firstly, the improbability (as manifested by the decreasing ratio of the ayes to the noes in the House of Commons' divisions) that Parliament would ever pass the bill; secondly, the improbability that, if passed, the Permissive Act would be largely adopted by local authorities; thirdly, the improbability that, if adopted, it would succeed in lessening intemperance. According to the mathematical principle of the composition of probabilities by multiplication, the probability that any good would ever result from an agitation costing more than a quarter of a million pounds, and extending already beyond a quarter of a century in duration, was practically *nil.* The only effective answers given to my arguments were those of the Rev. Mr. Steinthal and one or two others, who held that the probabilities in question are not altogether independent, because Parliament could hardly be forced to pass the bill unless there were extensive localities wishing to adopt it. There is a certain amount of truth in this objection, but it does not to any great degree strengthen the position of the Alliance. Their proposals in their original form seem to me to have the character of a vast experiment—so vast that it was intended to involve the extinction of the trade of publicans and liquor-dealers generally in all parts of the country. Now, that is an experiment, because it is exceedingly doubtful whether the population would tolerate such an interference with their habits, when the meaning of the act came home to them. The information which we can draw from Maine, or other places where prohibition of the traffic has existed, is most conflicting in itself, and remote in analogy. Accordingly, I should much like to see the prohibition of the public sale of liquor tried in several large English boroughs and districts, provided that the necessary act for the purpose could be carried without stopping all other legislation on the subject.

Within the last twelve months Sir Wilfrid Lawson and his followers have had the excellent good sense to drop the Permissive Bill, and proceed, by way of Parliamentary resolution, in favor of "local option." I really do not know exactly what is meant by "local option." Perhaps the Alliance itself does not know; the wisest course would be not to know—that is, to leave a latitude of meaning. In any case they have changed their policy. For year after year, for nearly the average length of a generation, it was the eleven clauses and one schedule of the Permissive Prohibitory Liquor Bill, pure and simple. Now it is "local option." Even if "local option" mean option of prohibition, a resolution is a more tentative method of procedure than the precise clauses of the celebrated bill. But if, as I fondly hope, "local option" will be interpreted to mean option for local authorities to regulate the liquor-traffic in the way thought to be most suitable to the locality, including prohibition when clearly desired by the inhabitants, then the matter assumes a much more hopeful aspect. Not only will the resistance to such a proposal be far less than to the Permissive Bill, but there will be considerable probability that when passed some successful experiments will be carried out. In fact, this "local option" would just be the mode of giving a wide field for diverse experiments which I am advocating. The teetotalers would be at liberty to try their experiments, but they would not in the mean time stop the progress of many other experiments, some of which might, in the course of ten or fifteen years, offer a sound solution of this most difficult problem. Of course, I am aware that this question of the drink-traffic is to a considerable extent a political one. There is a good deal which I might say upon this topic, but it would not be suitable to the tenor of my theme. If the political condition of England be such that the social reform of the people is not the main purpose of our Government, then we must hope that there are brighter lands where the political position is very different.

The best way of dealing with the liquor-trade would be to hand over the matter to the hands of a strong executive commission framed somewhat on the lines of the Poor-Law Commission. This body should have the power of authorizing schemes, proposed by local authorities, and should supervise the working of such schemes, and collect minute information as to the results. They would work entirely through local authorities, whether the corporations of cities and boroughs, or the benches of Licensing Magistrates. Before allowing any very serious experiments, such as the abolition of the public sale, the local authority would have to present evidence that the mass of the inhabitants was in favor of such a measure, and the Commissioners would then probably assign a suitable district, and authorize police regulations suitable for the most advantageous trial of the experiment. This method would carry out to the fullest point the idea of a "local option." Free licensing might be tried in Liverpool, and such other boroughs as liked to venture on such a hazardous experiment. The Gothenburg scheme would be adopted by Birmingham and a few other towns. Manchester might prefer the slighter measure of a rigid restriction and supervision of the public-houses. It is to be hoped that Sunday closing and a lessening of the week-day hours would be voted by many local authorities, and the experiment of remodeling the trade, as suggested above, ought certainly to be tried I should also much like to see some trial made of the important suggestion put forward by Dr. John Watts, at the last meeting of the Social Science Association. He suggests that in each town or district a limited number of licenses should be sold by public auction or tender. His purpose apparently is to limit the number of licenses, and yet to secure the profits of the monopoly to the community.

After the expiration of ten or fifteen years, Parliament would be in possession of a great amount of really practical information, but the probability is that it would not be found necessary to pass any great act for the subsequent regulation of the traffic. The scheme which was found to work best would by degrees be imitated in the districts of corresponding circumstances, just as the Gothenburg scheme is being imitated in other Swedish towns. I do not think that in a matter of this sort the final law need be exactly uniform. In the licensing act of 1872 it was found undesirable to fix a uniform hour of closing public-houses all over the country. Owing to the difference of habits, the metropolitan area was allowed one hour later at night, and considerable latitude was left to the Licensing Magistrates to vary the hours of closing. Surely such matters approximate more in character to hackney-cab regulations or matters of police, which have long been left to the borough authorities. It is only the political question looming behind the social or legislative question, which could warrant Parliament in deciding that people shall go to bed one hour earlier in the country than in London. But Parliamentary experience concerning the Licensing Act of the late Cabinet, and the now defunct Permissive Bill, can not encourage any party to press for a further great general measure of licensing reform. As to the present state of things, it could not be much worse nor more absurd. What with the great variety of kinds of licenses, the doubts and fears of the magistrates as to their powers of withdrawing licenses or restraining extension of premises, the remissness—to use a mild expression—of the police in prosecuting the offenses of publicans, and the universal facility of obtaining any amount of drink at the nearest grocer's shop—I say things really can not be much worse than they are. Under the vigorous exertion of local option the state of affairs would undoubtedly improve in some parts of the country; the pressure of public opinion, of the proposed Commissioners, or, in the last resort, of Parliament, would eventually force the negligent localities to follow the example of the most successful "local-option schemes."

Let it be understood that I do not for a moment suppose that there is much, if any, novelty in the proposals made above. In one place or another almost every suggestion, except perhaps that of a superintending Commission, has been made and discussed. The Lords' Committee have themselves recommended "that legislative facilities should be afforded for the local adoption of the Gothenburg and of Mr. Chamberlain's schemes, or of some modification of them." And the Lords have themselves recognized the value of social "experiments" in providing counter-attractions to the public-house. In their final report, dated the 17th of March last, they remark (p. xliv.):

> These experiments are too recent, and, in spite of their rapid increase, too partial and limited, to enable the Committee to pronounce with confidence on their ultimate success, or on the extent of the influence they may exercise in diminishing intemperance; but they desire to express their strong opinion that, if generally prosecuted and conducted with due regard for the wants and comforts of a population among whom education is gradually diffusing a taste for enjoyment far less coarse and gross than in the past, they are destined to have an important influence for good. It is obvious that the desire for recreation is felt by all classes alike.

What is this, however, but an express recognition by the House of Lords of the need of experimentation as regards the entertainment and recreation of the people? I fail to see how such experimentation either can or ought to be confined to philanthropists. If we look around and notice the vast new restaurants of London, the innumerable glittering railway-bars in all parts of the country, the music-halls of all ranks and kinds, the dancing and drinking saloons of some provincial towns—such as Nottingham—and the great enterprise with which such places of recreation as the Pomona and Bellevue Gardens at Manchester are conducted, we shall see that social experiments are not confined to the teetotalers. Indeed it would not be difficult to prove that the nugatory licensing laws, as now administered, present the least possible obstacle to the publicans in pushing their experiments, while they do prevent social reformers from interfering, or from establishing counter-experiments on an equal footing. It is hardly too much to say that the licensing laws are laws to give a license to the publicans and grocers to do what they like to extend the sale of spirituous liquors.

Although the liquor-traffic presents the widest and most important sphere for social experiment, there are many other matters to which it must be applied. Consideration in detail must show whether, in each case, the tentative method is or is not the proper method. But it is easy to name several other reforms which ought, in all probability, to be approached in the experimental manner. Thus, peasant proprietorship ought certainly to be tried in Ireland, as it was intended to be tried under the Bright clauses of the Irish Land Act. I am familiar with most of the economic objections to peasant proprietorship in this kingdom, and I have read sufficient of the large literature of the subject to know that evidence in favor of and against such a tenure of land is exceedingly divergent and perplexing. The proper resource, then, is to *try the thing*, not by some vast revolution in the land-owning of Ireland, as proposed by the late Mr. Mill—a measure which, in the first place, would never pass Parliament, and, if it did, would cost an enormous sum of money, and probably result in failure—but by a small and progressive experiment. "Earth-hunger" is a very potent passion, and I believe it is that from which the Irish people are really suffering. Bread and bacon are not the only good things an Irish peasant might aspire to; a place to call his own, a share of the air and sunlight of his native isle, and a land-bank in which to save up the strokes of his pick and spade, might work moral wonders. It is not safe to predict the action of human motive; but, at any rate, try it, although the trial cost as much as one or two first-rate ironclads, or a new triumph over a negro monarch. Surely the state of our Irish Poland is the worst possible injury to our "prestige."

Much doubt exists, again, as to whether imprisonment is necessary to enforce the payment of small debts. If needless, it is certainly oppressive. But if the abolition of the power of imprisonment, on the part of County Court judges, would really destroy the credit of the poorer classes with their tradesmen, a general measure to that effect would be dangerous and difficult to retract. I do not see how the question can be decided, except by trying the effect in a certain number of County Court districts, and watching the results.

It would be well worth the trouble to try the effect upon a certain body of inhabitants of the most perfect sanitary regulation, somewhat in the manner foreshadowed by Dr. B. W. Richardson in his "City of Hygeia." This I should like to see tried, as regards the middle classes, in some newly built watering-place, with full and special powers of sanitary regulation to be granted to it by Parliament, avowedly as an experiment. At the same time, a few large blocks of workmen's dwellings ought to be built and placed under experimental sanitary laws. I am convinced that legislation must by degrees be carried much further in this direction than is at present the case, but it ought to proceed tentatively.

One of the difficult questions of the present day is, How can London be supplied with water? There would be few engineering difficulties if it were allowable to separate the supply of pure water for drinking and cooking purposes from the much larger quantity required for other purposes. Will people drink the impure water? Who can decide such a question satisfactorily, except by experiment on a moderate scale? What could be more absurd than to spend millions upon procuring a separate supply of pure drinking-water for the population of London, and then finding that the population would drink the impure water? Many other like matters must be referred to trial, but it is not the purpose of this article to present a catalogue of experimental reforms, or to follow the argument out into all the possible details.

I am well aware that social experiments must often be subject to various difficulties, such as the migration of inhabitants, or even the intentional frustration of the experiment by interested parties. I have heard it said that the prohibition of liquor-traffic could not be tried on a small scale, because the publicans would be sure to combine to send liquor into the area. If they did so, the fact could readily be put in evidence, and, if they can defeat the teetotalers in detail, I am quite sure that they will defeat them upon any very great and general measure like the Permissive Bill. As to migration of inhabitants, it must be provided against either by suitably increasing the areas of experimental legislation, or else by collecting information as to the amount and probable effects of the migration. But the main point of my theme is to prove that we can not really plan out social reforms upon theoretical grounds. General argument and information of all kinds may properly be employed in designing and choosing the best experiments, but specific experience on a limited scale and in closely proximate circumstances is the only sure guide in the complex questions of social science. Our method must be that of the supremely wise text: "Prove all things; hold fast that which is good."—*Contemporary Review.*

CURIOUS WAYS OF GETTING FOOD.

By HERMAN L. FAIRCHILD.

TO eat and to be eaten would seem the necessity and the end of every living thing. Doubtless every plant may serve as food for some animal; and there is no animal which may not be meat for some other animal. Nature is a vast hunting-ground, where man and beast and every animated being are legitimate prey. Not alone do the carnivorous animals eat the herbivorous. The blood-loving tiger is itself the prey of parasites. Even proud man is living booty. Animals within animals; life within life. There is literal truth in the satirical passage:

"So, naturalists observe, a flea
Has smaller fleas that on him prey;
And these have smaller still to bite 'em,
And so proceed, *ad infinitum*."

The variety of animal food is, therefore, as broad as animated nature. Hence, we find great variety of means and methods for procuring subsistence. Particularity in food implies especial or efficient means of getting that food. The strange appendages of animals, their form, color, and habits, have to do more with the prehension of food than with any other function. It will be interesting to briefly survey the animal kingdom with reference to this marvelous adaptation. Its origin we will not discuss.

The simplest manner of procuring food is shown by the tapeworm and some other intestinal animals. These feed on the nutritive fluid prepared in the alimentary canal of the animals which they inhabit; and, being destitute of mouth and stomach, absorb the already digested food directly through the skin or body-walls. Probably this absorption does not require will or effort on the part of the parasite, but takes place simply by the physical action known as *osmose*. It is thus equivalent to the last step in the digestive process of higher animals. Some parasites, as the larva of the tapeworm, which live in the muscles and tissues, imbibe the animal juices by the walls of the body; but here the process as a whole is slightly higher, for this food probably requires more elaboration or digestion.

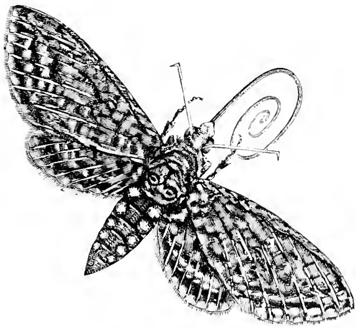

FIG. 1.—HAWK-MOTH (*Sphinx quinquemaculatus*).

Any special modification or organ for procuring food is a great advance beyond the method already described. Liquid food is more easily prehended than solid, yet the means are various and remarkable. Even the simplest organs are wonderful in their structure and action.

Those butterflies and moths which take any food at all have a long, slender tube for pumping the nectar of flowers. This "proboscis" is frequently much longer than the insect's body, and when not in use is beautifully coiled under the head. The humming-bird has a long, slender beak for the same purpose, which in some species is curved to fit certain flowers, it is said. Bees and flies lap their food, the former with a hairy tongue, the latter with a proboscis knobbed at the end. The sucker of the leech is furnished with three little saws for cutting the skin of its prey in order to draw its blood. A barbed tube is used by the louse; while the irrepressible mosquito is provided with a whole set of surgical instruments. Its proboscis, which seems so simple to the unaided eye, is found to be a "flexible sheath inclosing six distinct pieces, two of which are cutting-blades or lancets, two notched like a saw with reverted teeth, a tubular canal, and the central one an excessively acute point, which is also tubular."

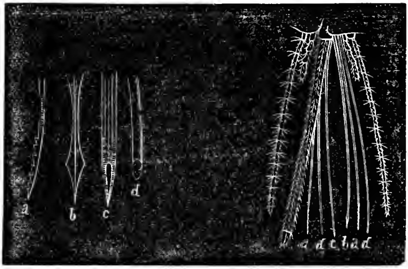

FIG. 2.—MOUTH-PARTS OF MOSQUITO.

It is interesting to know how the insect uses so many instruments, as we have all had the pleasure of being the subjects of her surgical skill (for only the female is admitted to the practice of bloodletting). "When the attack is made, the gnat (or mosquito) brings the tip of the organ within its sheath to press upon the skin into which it presently enters, the sheath remaining without and bending into an angle as the lancets descend. When the weapon has penetrated to its base—a distance of one sixth of an inch or more—the lancets move laterally and thus cut the flesh on either side, promoting the flow of blood from the superficial vessels; at the same moment a highly irritative fluid is poured into the wound, which has the effect of diluting the blood and thus rendering it more capable of flowing up the slender central tube into the throat of the insect."

Many aquatic animals, especially the low, fixed forms, depend for subsistence upon the minute organic particles floating in the water. But if the animal can not move in search of food it must have some means of bringing the food to itself. This is frequently accomplished by vibrating hair-like appendages, called cilia, which produce currents in the water. In that immense aggregation of minute animals, the sponge, the canals ramifying through the mass are lined with cilia, which cause constant currents of water to pass in at the small pores and issue at the large openings. Thus "the sponge represents a kind of subaqueous city, where the people are arranged about the streets and roads in such a manner that each can easily appropriate his food from the water as it passes along." Cilia fringe the gills of the bivalve mollusks, like the oyster and scallop, or the clam, which can burrow in the sand and send up into the water a long tube or siphon.

The great Greenland whale subsists on the small animals which swarm in the Arctic seas. But how shall the enormous beast capture sufficient of those tiny creatures? Its apparatus is as remarkable as it is unique—a huge sieve, made of the fringed edges of hundreds of "whalebone" plates, hanging from the roof of the mouth. Filling its cavern-like mouth with water containing the small animals, these are strained out as the water is expelled.

Solid food in mass requires some means of grasping—true prehension; generally accompanied by the power of dividing or crushing—mastication. A most curious method, and but one step higher than shown in the tapeworm, is exhibited by the microscopic amœba, found in fresh water. An animal without any permanent appendages whatever, a bit of almost structureless protoplasm, it nevertheless moves without limbs, breathes without gills, seizes food without prehensile organs, and digests without a stomach. All the animal functions are performed by the general mass of the body. Its mode of feeling is as follows: When a nutritious particle comes in contact with the body, the surface at that point begins to depress or fall in, and so continues until the surrounding surfaces meet and unite. In other words, the animal wraps itself around the particle, and the bit of food is enveloped in the albuminous body-mass. The nutritive matter is absorbed, and any undigested or waste matter is expelled by a reverse process. Briefly, the amœba extemporizes a stomach upon the place and at the time it is needed, and is not troubled with that uneasy organ when it is not needed. The ills of dyspepsia are to the amœba unknown.

The polyp or sea-anemone has numerous grasping arms called tentacles surrounding the mouth, which is at the top of the stump-shaped body. But the muscular power of the soft, watery animal is not sufficient to hold a lively crab or other struggling prey. To supplement this weakness, it is provided with a most marvelous and deadly apparatus. The surfaces of the tentacles, and frequently of the stomach and body-walls, hold countless minute sacs containing beautifully coiled filaments, which are quickly thrown out like so many poisoned darts to pierce and paralyze the victim. The structure and action of these stinging threads is one of the greatest wonders of nature. The weak jelly-fish uses the same means to overpower its prey, which, enveloped and paralyzed by the hundreds of thread-like tentacles, is drawn upward into the digestive cavity. The larger jelly-fishes, with tentacles streaming out to a length of thirty or forty feet, could easily paralyze large animals. It has been suggested that some of the sudden and strange disappearances of bathers may have been caused by these fearful creatures.

Hundreds of little air-pumps are employed by the star-fish. These sucking-disks upon the under side of the flexible rays enable the animal to adhere with surprising power. And it can also protrude its stomach to inwrap prey which is too large to swallow. It is thus able, by turning itself inside out, to suck an oyster from its shell; and, having an especial fondness for these mollusks, it makes great havoc among the oyster-beds.

The tongue is the prehensile organ of the univalve mollusks. Being covered with rows of toothed plates it acts like a rasp, or can be protruded beyond the head to serve as a drill. The vegetable-feeding snails have also a bony plate in the roof of the mouth to aid in cutting. The common garden-snail has not less than 28,000 teeth on its strap-shaped tongue. These mollusks, and all animals hereafter mentioned, have the superior power of vision which, enabling them to discover food or pursue their prey, is of the greatest aid in getting food. The other senses are also aids to prehension.

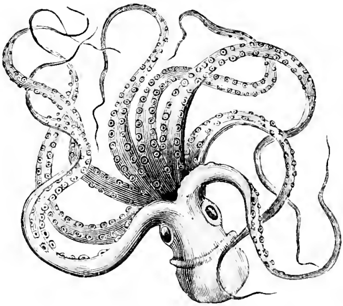

Fig. 3.—Common Poulpe (*Octopus vulgaris*).

The devil-fish, so called, the highest of mollusks, is possessor of an apparatus which for terrible efficiency could hardly be surpassed. Its prey is seized by eight long "arms" which surround the mouth, and the grasp is assured by rows of sucking-disks on the inner side of these arms. Indeed, these diminutive air-pumps hold so firmly that an arm will sometimes tear from the head. Some species have in addition two other arms equaling the body in length, which are commonly folded beneath the head, out of the way. As the creature nears its intended prey, these two long arms are quickly projected and seize the victim by means of the suckers, thus serving a purpose similar to a harpoon or lasso. As the victim is drawn nearer, the shorter arms wrap around it and effectually prevent its struggles. Now comes in play another instrument, its powerful, horny jaws, which form a beak shaped like a parrot's inverted. With this terrible weapon it bites its victim in the back of the neck, thus cutting the spinal cord and producing immediate death.

FIG 4.—PROTRUDED ŒSOPHAGUS OF A SEA-WORM.

How different is the method employed by the Laodicea! This worm inverts or protrudes its gullet as a sort of proboscis, provided at the end with little teeth for grasping. Like the star-fish, to seize its food, it turns itself inside out.

Biting insects and most articulates have horny jaws moving horizontally. Poison fangs are sometimes added, as in the centiped. The claws of the crab and lobster are transformed legs; one frequently used as an anchor, while the other holds the prey.

Every one is familiar with the skillful trap which the spider sets for his victims. This wily creature sometimes builds a concealed lair whence it can spring upon its prey. Others, that spin no web, have a curious fashion of fastening a thread to whatever object they stand on at the instant they pounce on their prey, in order that the victim,

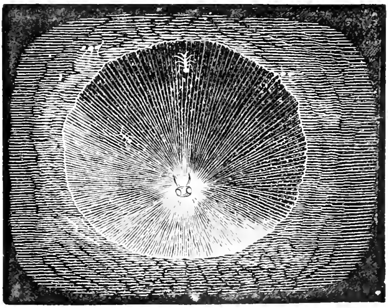

FIG. 5.—PIT OF ANT-LION.

which is frequently larger than the spider, may not fly away with its captor. It does fly to the extent of the thread, but the poison soon takes effect, and the cruel spider deliberately winds up its anchor cable and recovers its footing.

A relative of the dragon-flies, the ant-lion, when in the larval state, digs a conical pitfall, at the bottom of which it lies buried, with only its strong jaws projecting. Here it patiently waits for an ant or some small creature to tumble in. If the struggling animal seems likely to clamber out, the ant-lion hurls sand at it to bring it within reach of the fatal jaws, where it is surely lost.

Ants sometimes undertake the dairy business. Being exceedingly fond of a milky fluid which exudes from two tubes situated on the hinder part of the bodies of certain plant-lice, called aphides, to procure it they resort to measures strangely intelligent for even the proverbially wise ant. They have been known to build mud stables in which the aphides were kept as stalled milch-cows. To cause the flow of milk, the ants irritate or rub the tubes with their antennæ.

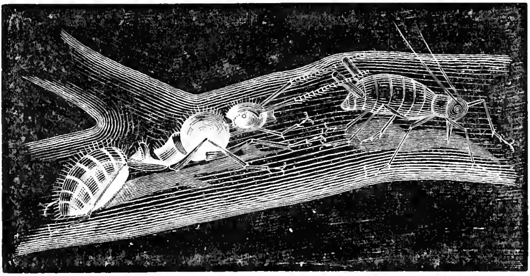

Fig. 6.—Ant milking an Aphis.

With few exceptions fishes depend upon their numerous teeth for seizing food. The sturgeon is toothless, and draws in its food by suction. A single long tooth is used by the hag-fish to transfix its victim, while it bores the flesh with a long, spiny tongue. The angler lies half concealed by sand and weeds, with its enormous mouth agape ready to seize any small fish which may incautiously venture near. Upon its nose is a long, flexible spine, with shiny tip, which, waving in the water, decoys small fry to their death.

King of fishes, by virtue both of size and ferocity, is the rapacious shark. This terror of the sea has its mouth armed with hundreds of teeth, triangular in outline and serrated on the edges. There are several rows, and, as the outer old teeth drop away, others rise into position to take their places.

In Japan is found a beautiful fish which has a sort of gun for bringing down insects. It does not have to wait, like other fishes, for the fly to fall into the water by accident. Seeing one lighted near the water, the chætodon gently approaches, and, aiming its beak, blows a drop of water with unerring aim, knocks the unsuspecting fly off its perch into the stream, and devours it, doubtless with a relish begotten of its skill as a sportsman. An air-gun with a drop of water for a bullet! It is said the Japanese amuse themselves by watching their captive chætodons shoot the flies presented to them.

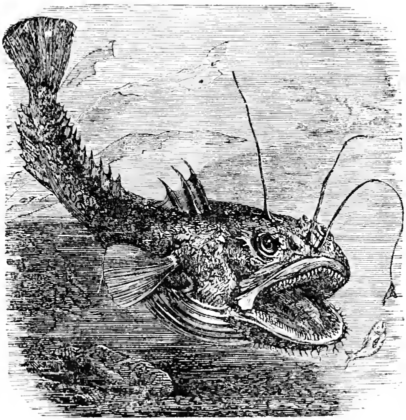

FIG. 7.—THE ANGLER (*Lophius piscatorius*).

Most reptiles use teeth for prehending food, like the fishes. Some, however, as the toad and chameleon, employ the tongue, which, being rooted in front and free behind, besides being very extensile, is thrown out and over with great quickness and precision. A sticky saliva causes the insect to adhere.

Poison-fangs of serpents are helps to procure food as well as weapons; and the power of charming is a very strange and effective way of obtaining food.

The alligator will approach a large animal which may be standing at the water's edge, and, by a quick blow of its powerful tail, knock the unsuspecting creature into the water. In deep water it is at the mercy of the reptile, which kills it by drowning. The nostrils of the alligator and crocodile are so placed as to be out of water, while the prey held in the jaws is beneath the surface.

Birds have not great variety of organs or methods of prehension. Beaks, claws, tongues, and keen senses complete the list of means. The woodpecker drills a hole into the tree to secure the larva which by some myterious power it knows is buried there; and its barbed tongue is used to draw the worm from its hole. The slender, forked tongue of humming-birds is used to grasp and draw minute insects from the depths of flowers. The long beaks of some birds are used to penetrate the sand or mud in search of worms. Birds of prey grasp with their talons. Their sight is wonderful, enabling them to discover their quarry at a great distance, and to strike it without error, notwithstanding the velocity of their approach. The sense of smell would seem remarkably developed in certain carrion-eating birds. The secretary-bird kills the poisonous serpents which are its diet by kicking them, while our domestic fowls scratch for a living.

Fig. 8.—Tongue of Woodpecker.

In variety of prehensile means mammals far surpass any equal group of the animal kingdom. Owing to our familiarity, however, these peculiarities seem less interesting; but, if we could divest ourselves of preknowledge, or see them with a new vision, we should be astonished and delighted by the various contrivances and the curious adaptations. The tongue is the chief or only prehensile organ of many animals. Here belong the ox and all the cud-chewers. Of these the giraffe is the strangest. Intended to browse, it has an extremely long neck, mounted on equally long legs and shoulder-blades; yet, lest it should still fail of reaching its dinner, the tongue is proportionately long and remarkably prehensile; being able to select the sweetest foliage, or extend so slenderly at the tip as to enter a hole the size of a quill. Its lingual dexterity is sometimes exercised to the discomfiture of visitors at the menagerie. The toothless ant-eater breaks down the hard mounds of the ants or termites with its powerful claws, and sweeps the insects into its mouth with an immensely long, worm-like tongue; or it may thrust the tongue directly into the ant-holes. The insects adhere by means of a glutinous saliva, as in the case of the toad.

The hog uses his nose for getting food, and the star-nosed mole has a similar contrivance. The lips are employed by the horse; and we find both nose and upper lip prolonged as a proboscis in the tapir and shrew. But the elephant is, of course, the great example of immense proboscis. The whole make-up of the animal is queer, and to a stranger would be absurd. The small boy who described the elephant as "a large beast with a tail at both ends" had the elements of a naturalist. As the neck of the huge creature does not permit great motion of the head, the trunk supplies the deficiency. The tusks are also chiefly food-gatherers; used as picks and spades for uprooting trees and digging succulent roots. The tusks of the walrus are certainly locomotive and defensive organs, but it is suggested that perhaps they are also used to raise algæ from the rocks of the sea-bottom.

The greater number of mammals depend wholly upon the jaws and teeth for grasping food. A full description of these organs more properly belongs to the subject of eating food. Gnawing animals, like the rabbit, have the four front teeth, incisors, acting as chisels. In the hippopotamus the prehensile teeth form tremendous shears for cutting plant-stems.

Beasts of prey use jaws or feet, or both ; but, to bring the prey within reach of either organ, requires keen senses to discover, and

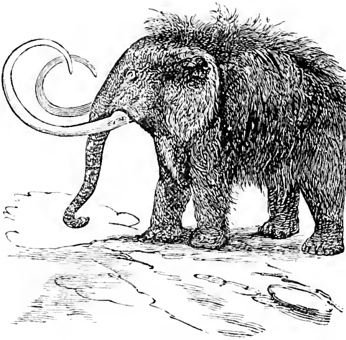

Fig. 9.—The Mammoth, or Hairy Elephant.

craftiness and speed to catch them. Animals of the dog tribe seize with the jaws ; those of the cat tribe use all four feet. The supple paw, with its retractile claws, is highly fitted for grasping and tearing, as well as for silent, stealthy tread. The cat's tongue is armed with spiny, recurved papillæ, to lap blood or scrape flesh from bones.

Monkeys also employ all their feet for grasping ; and, in common with those mammals that can sit on their hind-limbs, such as the squirrel, rat, kangaroo, and bear, carry food to the mouth with the fore-limbs ; and some monkeys use the sensitive tips of their long tails to draw fruit from crevices or holes. The strainer of the Greenland whale has been described. A shovel-bill is the appliance of the duck-mole.

Only reference can here be made to the adaptation of mammals to the element in which their food exists. The whale, seal, hippopotamus, and duck-mole, find sustenance in the water. In the ground burrows the mole ; the squirrel and sloth inhabit the trees, while the bat searches the air. Thus every element contains representatives of this highest animal group.

Prehension of food is so various in means and methods that no universal laws regarding it can be formulated. It can not form a basis of classification, seeming to have little or no discovered relation to animal rank. However, the subject is of greatest interest ; and, together with the adaptations of animals in other directions, has received in recent years much merited attention, chiefly in behalf of development theories. But, whether these remarkable adaptations of animals to peculiar food and surroundings be the result of variation and development, or of special creation, they are equally wonderful.

THE PLEASURE OF VISUAL FORM.

By JAMES SULLY.

I.

IT is often said that the pleasure of form as contrasted with that of color is an intellectual pleasure arising from the perception of relations (unity in variety, proportion, etc.). In a sense this is true, for, as I hope to show in the course of this essay, the appreciation of form as compared with the enjoyment of color is saturated, so to speak, with the more refined sort of intellectual activity. But the fact that certain varieties of the arts of form, more especially outline drawing, dispense with the pleasure of color, and even with that of light and shade, suggests that the pleasure of visual form includes a sensuous element as well as an intellectual. It will be my special aim in this paper to bring out this somewhat neglected factor in visual gratification, and to indicate, so far as it is possible, its importance among the several factors, which together compose what we call beauty of form.

In pursuing this inquiry, it will be best to disregard the sensuous enjoyment of light and shade. For our present purpose, differences of light and shade are merely means of appreciating form. Again, it will be advisable to include all varieties of form as determined by the three dimensions of space. It is true that beauty of form, so far as it rests on purely visual feelings, is largely that of surface relations or of space in two dimensions. Yet it will be found to be practically impossible to treat of this apart from that other kind of beauty of form which embraces the charm of distance and perspective, and the characteristic attractiveness of solid shapes. As to the order of treatment, I shall set out with the elements of pleasure which are obviously direct—that is, arise from the activity of the visual organ—and trace the process of building up a more complex intellectual gratification on these. After that I shall pass to the indirect or associated elements of enjoyment. The simplest kind of visual appreciation of form is that of linear relations. For reasons to be spoken of presently, a straight line is the natural element of visible form, and the development of the visual perception of form (regarded as independent of that of the tactual) proceeds by a kind of synthesis of linear elements. We may therefore confine ourselves for the present to this kind of form-intuition.

There are two ways of perceiving a line: either the eye may move along it, and appreciate its direction, length, etc., by the aid of movement; or it may fix the line, and estimate it by means of the impressions it simultaneously makes on different retinal elements. I shall assume here what is held by German writers like Lotze, Helmholtz, and Wundt, as well as by most English psychologists, that the former is the earlier method. This, then, is the simple experience into which we have first to look for the germ of the enjoyment of form.

A. SENSUOUS FACTOR.—We must imagine the eye, and first of all one eye apart from the other, moving as it now does, but having, instead of an extended retina, a single sensitive point at the center of the yellow spot, which is successively directed to different points in the outline of an object, with no other change of feeling than that which is connected with the movement itself.* It is plain that this experience will exactly resemble that of following a moving object, as a shooting star, with the single difference that in the former case the rapidity of movement will be a matter of choice. In order to understand the kind of æsthetic experience which the eye would have under these circumstances, it is necessary to say a word or two about its mode of action. I shall suppose that the reader is acquainted with the general features of the mechanism of ocular movement, and content myself with specifying one or two facts having an important bearing on our subject.

First of all, then, I would remind the reader that, setting out from the natural or "primary" position in which the axis or center of vision is directed to a point immediately in front of it, the eye is able to follow any line in the supposedly flat field of vision without a great expenditure of muscular energy, and with a uniform action of one or more muscles.† In other words, it is the simple and normal mode of visual action to describe a movement which answers to a straight line on the flat field. But, though all rectilinear movements from this primary position are normal ones, some are easier than others. Thus, while horizontal movements only require the action of one muscle, vertical movements involve two, and oblique movements three.‡ Movements far away from the primary position to points near the periphery of the field clearly involve a greater degree of muscular expenditure, the muscles in this case being contracted to their extreme limit. Further, it is noteworthy that in these outer regions of the field movements are no longer executed with the same simplicity. Thus, if the eye follows an horizontal line lying high in the plane of vision, more

* This supposition is not really conceivable, since a plurality of retinal elements is necessary to the eye's *following* any line.

† In this primary position the tension of the antagonist muscles is just balanced, and movement involves the first and easiest stages of contraction and relaxation.

‡ See Wundt, "Physiologische Psychologie," pp. 536–539.

than one muscle is involved. To sum up, the eye, owing to the laws of its mechanism, follows a line much more easily in the central than in the peripheral parts of the field, and in the central parts it follows a vertical line more easily than an oblique, and an horizontal more easily than a vertical.

It would seem to follow, from these conditions of facile movement in monocular vision, that in the case of binocular vision movements with parallel axes will be easier than movements with convergent axes. And this is proved by observation, for, as Wundt points out, infants instinctively move their eyes in the former way. Combined movements with convergent axes constantly involve an extra element of muscular tension, namely, that which is required to counteract the natural tendency to parallelism.* For the rest, it is to be noted that, with respect to "movements of convergence" (which cause the axes to approach one another, or *vice versa*), the symmetrical movements, which would be executed in following a receding line in the medium plane of the body, have so far a natural superiority over asymmetrical ones that, in the former case, the movements of the two eyes are exactly similar, in the latter case not so. The greater sense of ease which accompanies such symmetrical movements is probably explained, in part at least, by the constant need of executing such movements in passing the eyes from near to distant points lying in this medium plane.

Let us now pass to the subjective aspects of ocular movement. Although there is still a good deal of uncertainty respecting the exact composition of the feelings of movement, it may be taken as fairly proved that they include an active element or "feeling of innervation," which is correlated with the central excitation of motor fibers, and a passive element or tactual sensation which is connected with a reflex excitation of sensory fibers, consequent on certain differences in the tensions and mutual pressure of various parts of the skin which result from the movement.† The recognition of this twofold element in the feelings of movement may help us in understanding the pleasures of ocular movement.

It will, I think, be admitted as a truth, which is both borne out by direct experience and deducible from more general principles, that every movement of an organ is accompanied by at least a slightly pleasurable feeling, provided it has an appreciable duration and rapidity, and on the other hand is not excessive, whether as violently rapid, or as unduly prolonged in time, or repeated, or, finally, as unduly pro-

* It is to be added, however, that in the case of movements with convergent axes, directed to a point immediately in front of the two eyes, the contrast between horizontal and vertical movements, pointed out in the case of monocular vision, seems to be somewhat modified, though hardly obliterated.

† It is probable that this passive element includes the mental concomitant of an excitation of the sensory fibers which are known to run to the muscles themselves.

longed in space, or carried beyond the limits of ordinary and easy muscular contraction. The movements of the eye will be found to illustrate this law, though, owing to the small caliber of the ocular muscles, both the enjoyment and the fatigue attending them are apt to seem insignificant quantities. The pleasures of ocular movement are thus confined within definite limits, namely, a certain duration of a certain velocity of movement over the central part of the field of vision. Further, movements involving a higher degree of muscular expenditure grow fatiguing sooner than others, as we may see in the case of following the outline of very near objects with convergent axes. Finally, certain combinations of muscular action give rise to fatigue sooner than others, e. g., those necessary to oblique movement sooner than those involved in vertical or horizontal. The reason of this may be not so much the larger number of muscular factors as the relative infrequency of the combination. We have in a general way much more need to execute vertical and horizontal movements than oblique ones, height and lateral distance being the two most important dimensions; and this would tend to make the former easier and less rapidly fatiguing. For a like reason, the superior ease of horizontal movements may be referred in part to the greater need in general of attending to lateral relations of distance than to vertical ones.

Within these limits of pleasurable ocular movement we may find a difference in the quality of the enjoyment, according as the movement is energetic (though not excessively so) or comparatively restful. In the first case the feeling is of a more active and stimulating quality, and approaches in character the sense of power which we experience when we employ the larger muscles of the body. In the second case the feeling is more passive and allied to sensation proper. It may be thrown out as a conjecture that the former mode of pleasurable feeling is connected with the excitation of the motor fibers, whereas the latter consists mainly of the tactual and other sensations already referred to. We may, perhaps, conceive that, when the motor innervation reaches a certain degree of intensity, its mental correlative becomes the predominant feeling; but that, when it falls below this point, the passive sensations come to the surface of consciousness, so to speak, and give the dominant character to the feeling. On the whole, the gentler forms of ocular movement yield richer enjoyment than the more energetic. The muscles of the eye hardly seem to be of a sufficient caliber to supply the full consciousness of active force, which is a concomitant of the energetic action of the larger muscles of the body. Hence it may be said that the quieter forms of motor enjoyment are preferred by the eye.

This difference in the quality of the agreeable feelings of ocular movement is best seen in comparing slow and rapid movements, as in following the progress of a rocket in its early and later stages. As Professor Bain remarks, rapid visible movements are stimulating, while slow ones are more voluptuous and allied to the richer varieties of passive sensation. In following straight lines, and in tracing the outlines of objects, the eye has, it is obvious, a choice out of an indefinite number of velocities of movement. It is probable, for the reason just given, that under these circumstances it usually prefers a slow to an excitingly rapid species of movement.*

For a similar reason those directions of ocular movement which answer to easy and habitual muscular action, have more of a pleasurable character than those which soon approach the threshold of fatigue. Thus, an horizontal line is, as a rule, in itself, and apart from any extraneous consideration, more enjoyable, because more restful, than a vertical. Let the reader compare the feelings he has in looking at architecture, in which the vertical direction predominates, and at the approximately horizontal lines of a flat landscape. A somewhat analogous difference exists between movements of the two eyes with strongly converging and with parallel axes. The sweet repose of distance arises in part from this comparatively relaxed form of muscular activity.

So much as to the pleasure of single ocular movement. Let us now see how a pleasant succession of movements is to be secured. The conditions of agreeable sequence of movement seem to be the combination of the refreshing and stimulating element of change with an element of smoothness or ease of transition. Change of movement is, of course, necessitated by the universal condition of mental life, and variety is the very essence of all æsthetic experience, all monotonous feeling being wearisome. On the other hand, a chain of varied movements may be smooth and agreeable, or jerky and harsh, and this difference is related to the innate mechanical conditions of movement, and to the effects of habit.

Change of movement may most easily be secured by a variation either of velocity or of direction.† One and the same movement may vary in velocity, as in watching the ascent or descent of a projectile thrown up vertically. So different movements may present a difference of velocity as in the sequences of a ballet. Such contrasts plainly answer to the most favorable mode of expending motor energy. Again, our movement may be followed by another of different direction; that is to say, one that involves the action of fresh muscular elements, or a change in the relative amounts of action of two or more combining muscles. All complicated movements of objects and all arrangements of lines in the figures of bodies supply such variation in abundance.

So much as to change of element. Let us now pass to the other condition of agreeable sequence, namely, smoothness. The first and

* A certain rapidity is no doubt made natural by the need of visually construing objects as wholes.

† Change of duration and extent of movement will be best spoken of later on.

most obvious way of realizing such smoothness is by reducing the degree of change or contrast to a minimum. In this way we get a gradation of movement either in respect of velocity or of direction.

Gradation in direction or velocity, like gradation in shade of color or pitch of tone, is attended by a peculiarly agreeable feeling. One and the same movement may exhibit a gradual rise and fall of velocity, and it is probable that this is the form of movement naturally produced by all muscular contraction. Gradation in direction, which is at the basis of all curvilinear movements, depends on a gradual alteration in the relative degrees of activity of two or more muscles, and so corresponds to gradation in color or tone, which is supposed to rest on a continual increase of activity in certain nerve-elements, and decrease in others. A mode of gradation somewhat similar to that in direction is experienced in symmetrical movements of convergence, and especially in moving the axes from a near to a distant point, and so gradually relaxing the tension due to convergence.*

This mode of motor enjoyment is realized when standing in the middle of a building or an avenue of trees, and tracing an imaginary central receding line, and it is noticeable that we naturally place ourselves in the position and execute this kind of movement whenever we wish to appreciate the effect of perspective. It may be added that a union of gradation of velocity with that of duration, as in tracing the path of a projectile across the field of vision, affords the eye its richest form of motor delight.

A graduated series of movements allows of the least exciting degree of the feeling of variety. If a more powerful effect of change is desired, the element of smoothness must be looked for in another way. A succession of different movements has a certain degree of smoothness if they are continuous and free from sudden pauses and jerkiness. This can only happen if the movement is continuous in time, and, what is implied in this, in space—that is to say, the second movement must be one which can be commenced in that position of the eye in which the first has left it. Where this is not the case, there must be a "spring," so to speak, of the eye, to the new starting-point, which counts as an appreciable element of roughness or unevenness.

A higher degree of fluency is attained when the muscles, successively employed, are organically connected one with another, whether by some innate arrangement or by the influence of habit. This applies more especially to the action of the antagonists. A movement of the eyes to the left of the field produces a tendency in the antagonists to pull them back again. Hence the natural disposition to trace

* A rectilinear movement of the eye away from and back to the primary position may be said to afford a faint feeling of gradation, analogous to that experienced in movements of convergence.

a line forward and backward. Assuming the primary position to be the natural one, we may argue that any movement of the axis of vision from the center of the field excites a tendency to a corresponding movement of return to the central point of repose. Any chain of visible movements, as those of a ballet, and any arrangement of lines will gratify the eye in proportion to the number of such balancing actions of the ocular muscles which it includes.

It is only one step more to say that a full degree of fluency of movement implies a simple rhythmic order in the successive movements. The muscles of the eye being symmetrically formed, it follows that the action of any one will be compensated by the action of another of the same duration (the velocity being supposed to be the same). In this way a certain amount of rhythmic or equal time-order is rendered agreeable by an innate organic arrangement, and quite independently of any conscious perception of time-relations.

And here we reach the limit of what can be called the organic factor of sensuous gratification in ocular movement, and trench on the properly intellectual enjoyment of perceived relations. The perception of proportion would no doubt be possible if the eyes were what we have so far imagined them to be—incapable of simultaneous impressions. The moving eye, like the moving limb, can appreciate relations of duration and of distance or time-rhythm and space-rhythm within certain limits. Yet such a coördination of successive elements would be certainly inferior to that of the actual eye, with its capability of simultaneous impressions. It would probably be inferior to the ear's perception of measure. Hence we shall do best to treat of the visual sense of proportion and equality of magnitudes in connection with that more complex organ with which nature has actually endowed us. To the consideration of this higher kind of perception let us now pass.

B. Intellectual Factor.—In endowing our imaginary eye with an extended retina which allows of simultaneous perception of form relations, we do not get rid of the elementary experiences of movement first dwelt on: we only transform them somewhat. There is good reason to think that actual movement enters into our customary perception even of smaller forms much more than is generally supposed. It may be added that what we call a simultaneous perception of form is often, as I shall have occasion to show presently, a sequence of simultaneous perceptions. But more than this, one may now contend, with a fair degree of confidence, that, even in the perception of form by the resting eye, motor elements are essential ingredients, however much they may be disguised.

I need not here expound or defend the hypothesis of local signs put forth by Lotze, and accepted with certain modifications by Helmholtz and Wundt. My concern here is to trace some of the æsthetic consequences of this hypothesis. It at once follows from this theory that the resting eye's perception of form consists of a mass of motor feeling ideally represented. In other words, it is made up of a number of imperfectly distinguished imaginations of movement in different directions, etc. And these representative feelings are very various in character, since we are vaguely aware that any fixed line, for example, offers a choice of movement in two directions, and of an indefinite number of velocities. Now, if we conceive that the feelings of movement thus represented in a confused aggregate are distinctly pleasurable ones, it must follow that such a condition, of what I may call the motor imagination, will be a highly agreeable one. It will involve a vague consciousness of a wealth of motor experience and a rich area of selection. It has been said that the possibilities of enjoyment in valuable possessions, as wealth and friends, often count more than the amount of actual enjoyment we are ever likely to get out of them. This remark may apply to that recognition of the possibilities of pleasurable movement which every beautiful form supplies to the resting eye.

The capability of simultaneous local recognition by the eye would seem in this way greatly to enrich its enjoyment of form. Our appreciation of a beautiful line includes a transition from a state of actual movement with its definite motor feelings to a state of actual repose with the imagination of movement only, and of relatively indefinite feelings of movement.

To verify these deductions, it would be necessary to show that all agreeable forms, up to the most beautiful, do answer to pleasurable ocular movements. In a general way this will be found to be so. A beautiful figure is one which selects such elements of form, together with combinations of these, as supply the eye with the more agreeable varieties of motor experience already spoken of. The selection of curved lines, the preference for horizontal lines (which seems to be exemplified in the feeling for bilateral symmetry), the taste for continuous forms or contour arrangements, for the grouping of parts about a center and for symmetrical balance (which answer no less to the natural conditions of easy movement than they do to the arrangements of the retina itself), all this seems to show how closely beauty of form is conditioned by the laws of agreeable movement.

At the same time, what we call a beautiful form is sometimes ready to sacrifice this pleasure of movement; and it does so just because it can command another kind of gratification—namely, an intellectual pleasure in the recognition of relations. To this new factor we may now pass. I have already remarked that the moving eye, capable of successive experiences only, would not attain to any very complex perceptions of relations of parts. The capability of the eye in the delicate discrimination of shades of direction and distance, and still more in the coördination of manifold details under some aspect of unity, seems to be inseparably bound up with the fact of simultaneous retinal impression. A word or two will perhaps make this clearer.

The substitution of simultaneous retinal perception of form for successive perception has the effect of bringing together the terms of the relations of variety and contrast, unity and similarity, under what is approximately one act of attention. If we watch the movements of a painter's hand as he draws the outline of a human figure on a canvas, our eye may attain a rough perception of the successive directions and distances; but how vague will this perception be as compared with that which we instantaneously obtain when the artist moves away from his canvas, and shows us these as parts of a permanent coexistent whole! In the former case we had to bring together by the aid of memory a number of impressions occupying some appreciable time: in the latter these were presented to us in one and the same instant. It must follow, then, that the perception of all relations, whether of dissimilarity or similarity, will under the circumstances become more definite and more exact.

Nor is this all the gain. The addition of simultaneous retinal appreciation introduces a new and finer standard in estimating the elements of form themselves. In the case of two lines, for example, which are nearly equal, or of two lines which are nearly parallel, the discrimination of magnitude and direction is finer when the lines are brought together and simultaneously perceived by help of the retinal impressions than when they are so situated that they (or their distances from one another) have to be successively estimated by the moving eye. It may be thought that these more delicate estimates are of more importance in science than in art; yet even in the latter the less obtrusive charms of form, more particularly that of the human face, involve this finer retinal appreciation. It may be added that, even when the former is too large to be easily taken in by the eye at rest, the retinal capability of simultaneous perception greatly assists in the clearer and more exact appreciation of relations. In estimating, for example, the symmetry of a tapering column, of a pyramid or of a human figure, the eye need not pass over the whole of the contour. It is sufficient if it describe a path answering to the axis of the figure; for in this case the perfect equality of any two opposed parts will be estimated by retinal perception, and the whole intuition of form will then consist of a series of simultaneous perceptions.

THE CRAYFISH.*

By Professor E. RAY LANKESTER.

"COMMON and lowly as most may think the crayfish, it is yet so full of wonders that the greatest naturalist may be puzzled to give a clear account of it." These words from Von Rosenhof, who in 1755 contributed his share to our knowledge of the animal in question, are cited by Professor Huxley in the preface to the careful account of the English crayfish and its immediate congeners, which forms the latest volume of "The International Scientific Series." The book is not designed for "general readers," those somewhat luxurious but presumably intelligent persons for whom so much scientific knowledge is chopped and spiced at the present day. It is, as we gather from the author's statement, intended as an introduction to serious zoölogical study, for those who will turn over its pages, crayfish in hand, and carefully verify its statements as to details of structure with scalpel and microscope. To these and also to those who are already well versed in crustacean anatomy, the book will have great value and interest; to the latter more especially, as showing how in the careful study of one organism we are "brought face to face with all the great zoölogical questions which excite so lively an interest at the present day," and as an exhibition of that "method by which alone we can hope to attain to satisfactory answers of these questions."

A crayfish is treated in this volume from the point of view of "science," and in the first pages we have some excellent observations (recalling earlier remarks of the author's in the same sense) directed to clearing up that mystery which good people will insist on throwing around that ever-more-widely-heard term. "Common sense," says Professor Huxley, "is science exactly in so far as it fulfills the ideal of common sense; that is, sees facts as they are, or, at any rate, without the distortion of prejudice, and reasons from them in accordance with the dictates of sound judgment. And science is simply common sense at its best, that is, rigidly accurate in observation, and merciless to fallacy in logic." In the preceding quotation, Professor Huxley is (in a legitimate and intelligible way) using the word "science" in place of "that quality of mental activity by which science is produced." Immediately afterward he speaks of science as the product of certain mental operations, in a passage which possesses great beauty while setting forth fundamental but neglected truths as to the source and scope of human knowledge. "In its earliest development knowledge is self-sown. Impressions force themselves upon men's senses

* The Crayfish: an Introduction to the Study of Zoölogy. By T. H. Huxley, F. R. S. New York: D. Appleton & Co.

whether they will or not, and often against their will. The amount of interest which these impressions awaken is determined by the coarser pains and pleasures which they carry in their train or by mere curiosity; and reason deals with the materials supplied to it as far as that interest carries it, and no further. Such common knowledge is rather brought than sought; and such ratiocination is little more than the working of a blind intellectual instinct. It is only when the mind passes beyond this condition that it begins to evolve science. When simple curiosity passes into the love of knowledge as such, and the gratification of the æsthetic sense of the beauty of completeness and accuracy seems more desirable than the easy indolence of ignorance; when the finding out of the causes of things becomes a source of joy, and he is accounted happy who is successful in the search, common knowledge passes into what our forefathers called natural history, whence there is but a step to that which used to be termed natural philosophy, and now passes by the name of physical science.

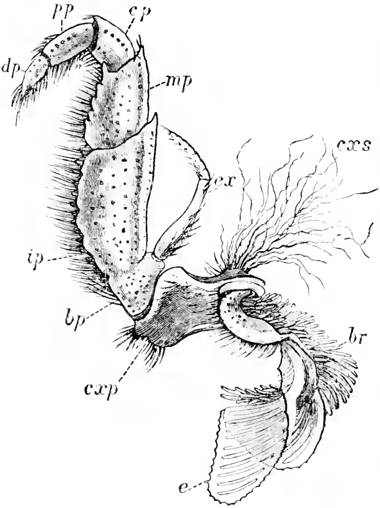

FIG. 1. ASTACUS FLUVIATILIS.—The third or external maxillipede of the left side (×3). *e*, lamina, and *br*, branchial filaments of the podobranchia; *cxp*, coxopodite; *cxs*, coxopoditic setæ; *bp*, basipodite; *ex*, exopodite; *ip*, ischiopodite; *mp*, meropodite; *cp*, carpopodite; *pp*, propodite; *dp*, dactylopodite.

"In this final state of knowledge the phenomena of nature are regarded as one continuous series of causes and effects; and the ultimate object of science is to trace out that series, from the term which is nearest to us, to that which is at the farthest limit accessible to our means of investigation.

"The course of nature as it is, as it has been, and as it will be, is the object of scientific inquiry; whatever lies beyond, above, or below this, is outside science. But the philosopher need not despair at the limitation of his field of labor; in relation to the human mind Nature is boundless; and, though nowhere inaccessible, she is everywhere unfathomable."

It is, then, with the object of arriving at a satisfactory conclusion as to the crayfish's place in nature, and to educe from the study of it such conclusions as may tend to throw light on the place in nature of other living things, that the reader is supposed to enter upon the consideration of the facts which Professor Huxley lays before him.

No pains have been spared in the illustration of the text—the woodcuts (eighty-one in number) reflecting great credit both on the artist for his skill and on the publisher for his enterprise. We have, after a general disquisition on the natural history of the crayfish (by

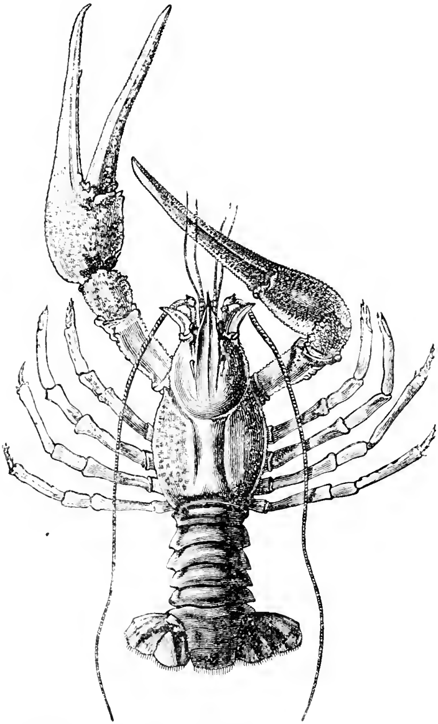

FIG. 2.—ASTACUS LEPTODACTYLUS (after Rathke, one third natural size).

no means the least interesting in the book), two devoted to the consideration of the crayfish as a mechanism—in fact, its physiology. Here a good deal of the anatomy is given and considered from the point of view involved in the question, "What does it do?" Then we have the morphology of the English crayfish—the structure and development of the individual minutely set forth, even each joint of each leg, and each tuft on each gill, and each group of hairs, being described and figured. We are enabled by the courtesy of the publishers to reproduce one of these highly finished engravings representing the most fully developed of the crayfish's limbs (Fig. 1), and some others which give a fair notion of the excellence of the illustrations of Professor Huxley's book.

To this follows a chapter in which the English crayfish is compared in a variety of points with crayfishes of other lands, such as those of Russia (Fig. 2), of Australia (Fig. 3), and of North America (Fig. 4), with lobsters and prawns, and it is explained how the amount of likeness and difference between these various but closely similar animals

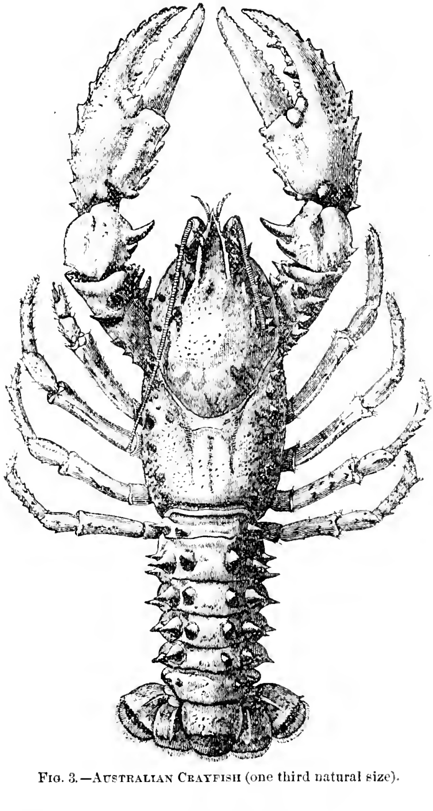

FIG. 3.—AUSTRALIAN CRAYFISH (one third natural size).

may be expressed by the method of classification in groups. Finally, we have a chapter on the geographical distribution of crayfishes, and the facts therein narrated, together with those adduced in the previous chapter, enable the author to sketch the probable pedigree of crayfishes, that is, to *refer them to their causes*, viz., to the action of such physical agencies as flowing rivers, land and climatic barriers, brought to bear upon successive generations of the offspring of *marine* lobster-like ancestors which had a wide distribution in the earlier Tertiary and later Mesozoic periods, and before taking to fluviatile life had separated into two distinct races characterized by differences of form, the one giving rise to the crayfish of the northern hemisphere (the *Potamobiidæ*), and the other to the crayfishes of the southern hemisphere (the *Parastacidæ*).

The novel portion of this book (novel at least to those who do not study the transactions of learned societies) is that in which Professor Huxley details the very interesting results which he has obtained by a minute examination of the gills attached to the bases of the legs and sides of the body in all crayfish and allied forms. Three series of these gill-plumes may be distinguished according as they are attached to the leg, to the joint-membrane, or to the side of the body (Fig. 5). An ideally perfect crayfish would have all three series complete on each ring of the body in the branchial region (including the region occupied by the three pairs of maxillipedes and the five pairs of walking and nipping legs). But no such realization of the ideal can be found in Astacine nature, any more than in that of the higher Catarrhines. In some crayfish more or less of the leg-gills are suppressed; in others, the body-gills; in others, the joint-gills; and, so ringing the changes on the combination of these elements, it is possible to construct clearly distinguished groups among the crayfishes of many climes, which at first sight seem to differ very little from one another. Further, Professor Huxley shows that crayfishes and lobsters differ from prawns, shrimps, and crabs, in having villous gills instead of laminated gills, in being "trichobranchiate" in place of "phyllobranchiate."

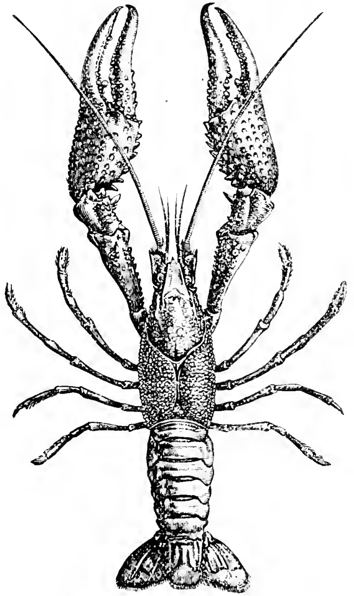

FIG. 4.—CAMBARUS CLARKII, male (half natural size), after Hagen.

It will probably not be welcome news to some of our readers that the English crayfish is in all probability not entitled to the current title of *Astacus fluviatilis.* This name appears to belong to a larger species, sometimes called *A. nobilis,* hardly distinguishable from the

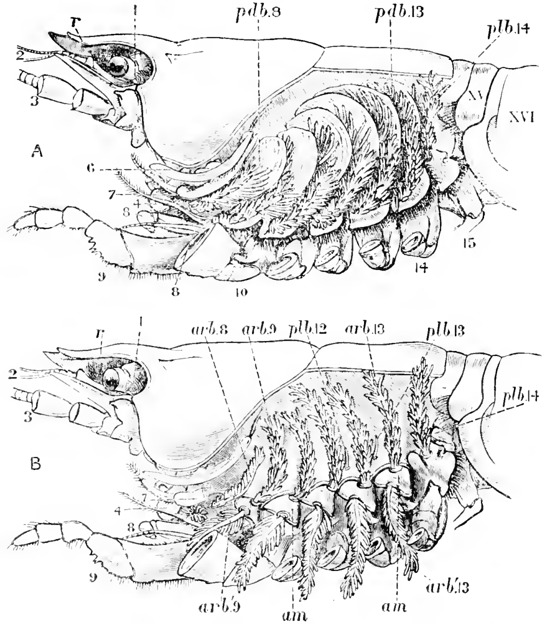

Fig. 5.—Astacus fluviatilis. In A, the gills, exposed by the removal of the branchiostegite, are seen in their natural position; in B, the podobranchiæ are removed, and the anterior set of arthrobranchiæ turned downward (× 2): 1, eye-stalk; 2, antennule; 3, antenna; 4, mandible; 6, scaphognathite; 7, first maxillipede, in B the epipodite, to which the line points, is partly removed; 8, second maxillipede; 9, third maxillipede; 10, forceps; 14, fourth ambulatory leg; 15, first abdominal appendage; xv., first, and xvi., second abdominal somite; *arb.* 8, *arb.* 9, *arb.* 13, the posterior arthrobranchiæ of the second and third maxillipedes and of the third ambulatory leg; *arb'.* 9, *arb'.* 13, the anterior arthrobranchiæ of the third maxillipede and of the third ambulatory leg; *pbd.* 8, podobranchiæ of the second maxillipede; *pbd.* 13, that of the third ambulatory leg; *plb.* 12, *plb.* 13, the two rudimentary pleurobranchiæ; *plb.* 14, the functional pleurobranchiæ; *r*, rostrum.

English one, which in France lives side by side with it. The smaller crayfish, which alone occurs in England, is known as *A. torrentium.* This specific title will, it is to be feared, have to be adopted, although it by implication casts a slur upon the river Isis. *A. fluviatilis* has red tips to its legs and a rostrum which differs by a notch or two from that of *A. torrentium.* Further, and this is very curious, *A. torrentium* never has been found to be infested by that very interesting parasite (more interesting even than the crayfish itself), the crab-leech, Astacobdella, or Branchiobdella, while it is quite abundant on the *A. fluviatilis*, at any rate in some rivers (e. g., the Saale, in North Germany).

A. fluviatilis is largely eaten in France, attaining to the very respectable size of five inches or so in length, while our smaller *A. torrentium* is neglected from this point of view. We can recommend it, however, when boiled in salt and water, as nearly if not quite equaling the prawn. The poisonous properties of the flesh of crayfish might perhaps be considered as justly falling within the scope of the first chapter of Professor Huxley's treatise. As in the case of many mollusca and some true fishes, there appears to be a substance present which acts as an irritant poison upon the human organism, and to its action some persons are more liable than are others, while certain conditions of the crayfish seem to favor the development of a large amount of this poisonous body. A case was recently reported, in a French medical journal, of the poisoning of six persons who partook of a dish of crayfishes—in one case with fatal result.—*Nature.*

LEARNING TO WRITE.

WE wonder sometimes, as we wade through a mass of correspondence, whether it is possible to teach good writing. The doubt may seem absurd, considering that the majority of civilized mankind can write, that every qualified teacher among one or two hundred thousand in Western Europe thinks himself or herself competent to teach the art, and that there must be some hundreds of men in England, or possibly some thousands, who make a living of some sort by practicing this specialty. Everybody, we shall be told, is taught, and some few people write well, and consequently to teach people to write well must be possible. Still, we have this little bit of evidence in favor of hesitation. Nobody ever saw anybody who wrote a thoroughly good hand, and who had been regularly taught to do it. Good handwritings exist, undoubtedly, and are, we should say, rapidly on the increase ; but the possessors of the art never admit that they acquired it through teaching, and, in the majority of cases, never were taught. When cross-examined, they always affirm that some man or woman taught them to write, and that then a certain inclination or compulsion of circumstance, or desire to do everything well, or, in frequent instances, a caste feeling, provoked them to teach themselves to write well. They were not taught, except in the most rudimentary sense of the word, and we do not know how they should be. Tutors and governesses have all caught up a system from the professional writing-masters, and the professional writing-masters are all dominated by two ideas, which are radically false. We always glance over the books they publish, and have read through a new one this week, which we do not intend to advertise in this article, and they are all alike. They all think that "copperplate writing," the special hand of writing-masters and bank-clerks, is good writing, which it is not, being devoid of character, far too regular in form, and from the multiplicity of fine up-strokes not easy to read; and they all believe that certain mechanical motions, if carefully taught, will produce clear writing. They will not, and they do not. There never were two people yet in this world of ours who wrote exactly alike, or who have the same control of their fingers, or who ought, in order to produce good writing, to have held their pens alike, and the effort to make them do it only spoils their natural capabilities. No doubt, those capabilities are often naturally very small. The number of persons who are by nature not deft with their fingers is very large, and so is the number of those who can not fix their attention; while the number of those who can do nothing well which they must do rapidly probably exceeds both. The difficulty of teaching a grown man to write decently is almost inconceivable—he seems never to see what is wanted—and something of that difficulty attaches to a vast proportion of children. Still, all persons not deformed or crippled in the hand, or deficient in eyesight, can be taught to write, and the reason why they are not taught properly must be some inherent defect in the system. We believe it to be the one we have mentioned, the effort to enforce a certain method, instead of trying to secure a certain result. The unhappy child, who is almost always, we admit necessarily, taught too early, is instructed to hold himself or herself in a particular attitude, which is sure to be the wrong one for five sights in ten, the proper attitude depending on the length of the child's vision; to hold the pen at a particular angle, which is also wrong, the fitting angle depending on the character of the pen and holder; and to grasp the pen at a certain distance from the nib, which is arbitrarily fixed, whereas the distance must be governed by the formation and strength of the child's fingers, and would be infinitely better left to his or her own instinct. Above all, there is a perpetual worry about the "resting" of the hand, though the easiest position varies with every child, and though no two men with much writing to do rest the fingers quite alike. The pupil is then taught to make lines in a certain direction, and to copy characters so large that they have no resemblance to writing at all; and to care particularly about up-strokes and down-strokes, and all manner of minutiæ, which, if they are of any value at all, will soon come of themselves. So strong, in spite of centuries of experience, is the belief in this method, that machines for controlling the fingers while writing have repeatedly been invented; and the author of a book before us, a professional, is inclined to tie them up in some fashion with ribbon.

We believe that the whole of this method is a mistake, that there is no single system of *mécanique* for writing, and that a child belonging to the educated classes would be taught much better and more easily if, after being once enabled to make and recognize written letters, it were let alone, and praised or chidden not for its method, but for the result. Let the boy hold his pen as he likes, and make his strokes as he likes, and write at the pace he likes—hurry, of course, being discouraged—but insist strenuously and persistently that his copy shall be legible, shall be clean, and shall approach the good copy set before him, namely, a well-written letter, not a rubbishy text on a single line, written as nobody but a writing-master ever did or will write till the world's end. He will make a muddle at first, but he will soon make a passable imitation of his copy, and ultimately develop a characteristic and strong hand, which may be bad or good, but will not be either meaningless, undecided, or illegible. This hand will alter, of course, very greatly as he grows older. It may alter at eleven, because it is at that age that the range of the eyes is fixed, and short-sight betrays itself; and it will alter at seventeen, because then the system of taking notes at lecture, which ruins most hands, will have cramped and temporarily spoiled the writing; but the character will form itself again, and will never be deficient in clearness or decision. The idea that it is to be clear will have stamped itself, and confidence will not have been destroyed by worrying little rules about attitude, and angle, and slope, which the very irritation of the pupils ought to convince the teachers are, from some personal peculiarity, inapplicable. The lad will write, as he does anything else that he cares to do, as well as he can, and with a certain efficiency and speed. Almost every letter he gets will give him some assistance, and the master's remonstrance on his illegibility will be attended to, like any other caution given in the curriculum. As it is, he simply thinks that he does not write well, instead of thinking that not to write well is to fall short in a very useful accomplishment and to be *pro tanto* a failure.

We are not quite sure that another process ought not to be gone through, before writing is taught at all. Suppose our boys and girls were taught to read manuscript a little? They are taught to read print, but manuscript is not print, or very like it, and they are left to pick up the power of reading that the best way they can; they never devote half an hour a day for six months to manuscript-reading. If they did, it would be easier to them all their lives, and they would learn to believe in legibility as the greatest, or, at any rate, the most useful, quality that writing can display—an immense improvement, if our experience can be trusted, in the usual youthful ideal on the subject. The business of life, no doubt, soon teaches children to read manuscript; but many of them never read it easily, and retain through life an unconquerable aversion to the work, from the fatigue and vexation which it causes them. We have known men so conscious of this defect that they always have important letters read aloud to them; and others who would refuse any work, however anxious on other grounds to accept it, if it involved the frequent perusal of long manuscripts in varied handwritings. No doubt the tendency to a broad and coarse but beautifully legible handwriting, which has conquered the upper class and is slowly filtering downward, is diminishing this reluctance, but it would be more rapidly removed if a little trouble were taken to teach children to read handwriting. They hardly see any till they begin to receive correspondence, and are never compelled to read any, and consequently learn to write what they can not read, without intelligence and without pleasure.—*Spectator*.

A CONSIDERATION OF SUICIDE.

By J. H. HOPKINS.

NICHOLAS RIDLEY and Hugh Latimer stood at the stake to be burned for heresy. Fastened to the body of each was a bag of powder, placed there by friends with the intention of bringing the sufferings of the victims to a speedy termination. Latimer died first. The flames, rising rapidly, touched the bag of powder, and the torture for him was at an end. Ridley was not so fortunate. The wood, prepared for his execution, being green and tightly packed, the fire smoldered, and he was long in agony, crying out that he could not burn; until one of the spectators having loosened the fagots and admitted air, the flame swept up to the powder and brought death.

It is certain that the use of powder was not included in the sentence of death. It was permitted, not authorized. Death being sure, the persecutors were magnanimous enough, at the last, to allow it to come quickly. As the Athenian tribunal granted the privilege of hemlock to Socrates; as the English executioners failed to carry out, literally, the horrible sentence of hanging, drawing, and quartering; so the Marian officials did not insist on the extreme rigor of the sentence. But was this hastening of death, in a way unauthorized by law, either murder on the part of the friends of Ridley and Latimer, or suicide on their own part?

Under the old, stern common law, literally construed, the martyrs who used and the friends who furnished the powder were guilty, the former of suicide and the latter of murder. "The law of England," says Blackstone (vol. ii., p. 189), "wisely and religiously considers that no man hath a power to destroy life but by commission from God, the author of it; and, as the suicide is guilty of a double offense, one spiritual, in evading the prerogative of the Almighty, and rushing into his immediate presence uncalled for, the other temporal, against the King, who hath an interest in the preservation of all his subjects, the law has, therefore, ranked this among the highest crimes, making it a peculiar species of felony, a felony committed on one's self. And this admits of accessories before the fact, as well as other felonies; for if one persuades another to kill himself, and he does so, the adviser is guilty of murder. A *felo-de-se*, therefore, is he that deliberately puts an end to his own existence, or commits any unlawful, malicious act, the consequence of which is his own death." The English laws further provided for the forfeiture of the goods and chattels of a suicide to the King. In the State of New York, a *felo-de-se* does not incur the penalty of forfeiture of property; but "every person deliberately assisting another in the commission of self-murder shall be deemed guilty of manslaughter in the first degree." (2 R. S. 661, § 7.) If a condemned criminal, on the eve of his execution, takes poison, he commits suicide. If, while standing on the scaffold, some one hands him a knife, with which he takes his life, he commits suicide, and the person who furnishes him with the means of death is guilty of manslaughter. If, just before the drop falls, some well-intentioned friend, deeming a speedy death preferable to a slow one, sends a bullet through the heart of the condemned, the friend is guilty of murder.

The relation of suicide to human laws it is not the purpose of this article to consider. Undoubtedly the tacit contract between the government and the individual, while it demands on one side protection to the individual, demands on the other side service to the state; and it rests with neither party to the contract to terminate it at pleasure. Every person, to a certain extent and within proper limitations, places at the disposal of the government under which he lives, his life, liberty, and property. The government becomes the trustee, and, as long as the trust is properly executed, the individual—the *cestui que trust*—has no right to interfere. But we are to consider suicide morally, not legally. The question to be answered is this: Is suicide ever justifiable?

What is suicide? The voluntary termination of one's own life. And this is very different from submission to or acquiescence in involuntary death. A man may long for the approach of death; he may embrace it eagerly when it comes; but this is not the voluntary termination of life. The voluntary termination of life implies some act or failure to act on the part of an individual, which has for its object, in whole or in part, the death of the actor. Suicide, then, is the voluntary termination of one's own life. Is it of any consequence that the involuntary termination is inevitable? Unquestionably not. Death, whether soon or late, is a creditor who never releases his debt; and, if in one case the certainty of death is pleaded in extenuation or justification, the same plea may be offered in every case. Does the proximity of involuntary death furnish any excuse for voluntary death? Certainly not. The hastening of death is the voluntary termination of life; and the voluntary termination of life is suicide.

If, then, the fact that death is near and inevitable does not make the voluntary termination of life anything less than suicide, may not the applicability of that word depend upon the motive which prompts such voluntary termination? Here, again, the answer must be in the negative. Keeping in mind the definition, let us suppose that two persons, shipwrecked at sea, find themselves clinging to the same fragment of the wreck, which is not buoyant enough to support both. Either both must drown, or one must push off the other and live by his death, or one must of his own will surrender the entire possession of the floating support to the other and seek death. In the first case death is accidental to both—they retain their grasp on life as long as possible; in the second case death is accidental to the one who is thrust from the support, and his companion is guilty of murder; and in the third case the one who surrenders possession commits suicide. "Greater love hath no man than this, that a man lay down his life for his friend"; but he who displays this great love is literally guilty of suicide. Have not many, whose memory the world honors, been guilty of this so-called crime? What was the act of the legendary Curtius, of the three hundred at Thermopylæ, of Arnold von Winkelried? What is the act of the engineer, who rides to death on his engine to save the lives of the passengers? What is the act of the cashier who, with the promise of death as a penalty for refusal to open the safe, prefers death to dishonor? Are not all these acts suicidal? It can not alter the character of the act that the voluntary termination of life is not brought about by one's own hand. Did not Saul commit suicide, when, at his request, the young Amalekite slew him? If a man, placed on a railroad track by enemies, but released a few moments before the approach of a train, refuses to leave the track and is killed by the train, will it be claimed that he is innocent of suicide? It is evident that, whether a person takes his own life without the intervention of any other agency than the person himself, or places himself voluntarily in a position where death is inevitable, or, being involuntarily placed in a position where death is inevitable, and a way of escape being provided, refuses to take advantage of it—in each and all of these cases the termination of life is voluntary and constitutes suicide.

This interpretation is too stern and hard; and people recognize the fact by refusing to call things by their right names. They do not say that Arnold von Winkelried committed suicide, but that he "sacrificed himself for his country." They do not suggest that John Maynard should be buried at cross-roads with a stake through his body, but assert that he has evinced the most sublime self-abnegation. If John Brown had been promised the freedom of four million slaves, on condition that he should voluntarily submit to death on the gallows, his acceptance of the condition would not have insured him condemnation, but apotheosis.

It becomes clear, then, that suicide is sometimes not only justifiable but praiseworthy ; and men make that justification or praise dependent upon the motive with which life is surrendered. To determine whether the voluntary termination of life is reprehensible or laudable, an answer must first be given to the question whether the act is selfish or unselfish, whether the motive is egoistic or altruistic. If the object is to save others from suffering, the act is justifiable. If the object is merely to save one's self from suffering, the act is unjustifiable.

This distinction between motives seems to be the true one, whether we look at suicide from the purely moral or from the religious and Christian standpoint. Take the Christian apothegm, "Greater love hath no man than this, that a man lay down his life for his friend," or, to put it still more tersely, "The greatest love is shown by altruistic suicide," and discover, if you can, where the line is to be drawn. Does it mean that a man should lay down his life only when, by so doing, he saves the lives of others? Then he may not submit to death, though by so doing he saves millions from slavery—nay, though by so doing he saves a world from slavery. Then he may not abandon life, though by that act he rescues others from eternal agony. Then he must not prefer death to dishonor, but dishonor to death. Then he must hold his own life as more valuable than the welfare of his race. If a promise were made, with the certainty of fulfillment, that should any human being voluntarily submit to death pain would disappear from the world, do you think that he who should give his life in exchange for the happiness of a world would be branded with the mark of crime?

But, if we take the next step and assert that there are other motives, besides the wish to save the lives of others, which will justify a man in voluntarily terminating his own life, where shall we draw the line? If a man may die for the happiness of a world, may he die for the happiness of a million? If he may die for the happiness of a million, may he die for the happiness of a thousand? If he may die for the happiness of a thousand, may he die for the happiness of ten? If he may die for the happiness of ten, may he die for the happiness of one? At what point does the happiness of others accumulate to such an extent as to exceed in value a human life?

Let us suppose a case—one of which experience furnishes numerous examples: A man, through some misfortune, finds himself wrecked and shattered in body; transformed into a living fixture. He can no longer support himself. He becomes a burden for some one to carry. If he is sure that the burden is borne willingly, he may consent to live. But suppose that the shoulders of the bearer ache, and that when death lifts the burden from him he draws a sigh of relief. May not the burden itself provide the way of escape and throw itself from the shoulders of its unwilling bearer to the shoulders of death? Or, take another illustration. Had Enoch Arden found that the only way in which his return could be kept secret, and his wife and family saved from misery, was by the sacrifice of his life, would he deserve condemnation if he had sought death?

It will be observed that the question has been discussed from an altruistic standpoint. This, of course, excludes Ridley and Latimer. It excludes all those who, threatened with death by disease, and whose life can be saved only at the price of some operation excruciatingly painful, decline to pay the price. It excludes all those who turn to death as a refuge from their own sufferings.

But, viewed in the light of pure altruism, when does suicide become justifiable? Each person must give answer for himself. Every individual is sole judge of the circumstances which justify a surrender of life. It is true that from this opinion orthodoxy dissents. It reasons thus: "Man has been placed upon the earth by God for some good purpose: it is fitting that he remain there until granted leave to return. Let him not enter the presence of his Maker unsummoned." But the same reasoning will serve the most selfish and cowardly egoism. Let the three hundred at Thermopylæ take to their heels, crying out that they will wait until God calls them. Let Arnold von Winkelried leave the field, protesting that he will not usurp the prerogative of the Almighty by assuming control of his own life. Let the men at sea cling to the floating fragment to the last, comforting themselves with the assurance that they have no right to determine for themselves whether their Maker has summoned them. Let the engineer abandon his train with the conviction that his duty to the Author of his being requires him to preserve his life. Certainly orthodoxy does not mean what it says. It cries aloud, "Wait until God calls you"; but adds, *sotto voce*, "Use your own judgment as to what constitutes a call." If it commands men not to take their own lives, it qualifies the command by urging them to lay down their lives for others. In fact, the assertion that men should wait until God summons them is merely putting the case in different language. For who is to decide what constitutes a summons? Evidently the individual himself. But to say that every one must determine for himself what constitutes a summons from God is to say that each person is sole judge of the circumstances which justify a voluntary termination of life.

From the Roman who, devoting himself and the enemy to the infernal gods, rushed to death to bring victory to his companions, to the suicides at the shrine of Juggernaut; from these to the man who "lays down his life for his friend"; from this to the engineer who sacrifices himself for the passengers; from this to the man who dies that thousands may be made happy; from this to the man who refuses to live when his life makes others miserable; from this to the man who turns to death to avoid becoming a burden to his friends—the descent is steady and connected. The last case may claim relationship with the first; and between all, filling up any imaginable gaps, are numberless other cases which belong to the same family. All these are cases of altruistic suicide. Who shall point out the place where suicide ceases to be honorable and becomes dishonorable? Who shall draw the line and say, "Thus far and no farther"? The later Stoics attempted it, and the distinction which they made was not unlike that of orthodoxy. "If you have no further need for me in prison," says Epictetus, "I will come out; if you want me again, I will return." "For how long?" "Just so long as reason requires that I should continue in this body; when that is over, take it, and fare ye well. Only let us not act inconsiderately, nor from cowardice, nor on slight grounds, since that would be contrary to the will of God, for he hath need of such a world and such beings to live on earth. But if he sounds a retreat, as he did to Socrates, we are to obey him when he sounds it, as our General." Here likewise the decision concerning what constitutes a summons from God rests with the individual. Each person determines for himself the propriety of terminating life.

Condemnation of even egoistic suicide should be indulged in cautiously. Epictetus, indeed, thought that it might sometimes be allowable. "But remember the principal thing," he says, "that the door is open. Do not be more fearful than children; but as they, when the play does not please them, say, 'I will play no longer,' so do you, in the same case, say, 'I will play no longer,' and go; but, if you stay, do not complain." The doctrine was this: A man is directed to play the game of life. God deals the cards. The man may receive hands with which it is impossible for him to win; yet he must play the game to the best of his ability. But suppose he detects his adversaries cheating. He may then throw down the cards and leave the table. It is not always safe to pronounce suicide unjustifiable, even where the motive is a wish to avoid self-suffering. I do not find it easy to regard Ridley and Latimer as criminals instead of martyrs. I do not consider myself competent to declare that he who receives harsh treatment at the inn of life is not warranted in curtailing his visit and returning home.

But, granting that egoistic suicide is blameworthy, who shall pass judgment upon the character of that suicide which has for its motive a desire for the welfare of others? Surely not man. He has no moral balance so absolutely true that he can safely weigh the motives which lead to suicidal self-abnegation, and pronounce some sufficient and others insufficient. Let the decision be left where it belongs—with Omniscience.

VEGETABLE PHOSPHORESCENCE.

By ELLEN PRESCOTT.

THERE is a curious myth which gives to Castor and Pollux, twin sons of Zeus, a divine control over the phosphorescence of air and ocean. Being present by invitation at the marriage of two youths of Amyclæ with the daughters of Leucippus, they became enamored of the brides and with the doubtful courtesy of the period attempted to carry them off. In the ensuing struggle Castor was slain; but Pollux, with a boundless and heroic love that bridged the "abyss 'twixt life and death," besought their father Zeus to restore him, proposing that to meet the ends of justice they should each live only on alternate days. This he granted, and, "kindling stars upon their brows, set them for ever with the immortals."

A religious idea was therefore involved in the superstition of the ancient mariner that the pale phosphoric light, or "St. Elmo's fire," which occasionally appears upon the masts of ships, in an electrical condition of the air, denoted the presence of these divinities as they rode upon the storm-clouds through the heavens. This indicates a recognition of the phenomena of phosphorescence in a remote antiquity; but, in advancing from the philosophy of myths and symbols to an era of empirical knowledge, there was necessarily a period of confusion, when old fancies were replaced by new facts which had not accommodated themselves to the novelty of the position. Even when, through the onward roll of centuries, the wisdom of the ancients had shrunken into grotesque fables, a long period intervened which produced no marked scientific results.

Throughout the seventeenth century inquiry was directed to the phenomena of solar light and the light of incandescent bodies; but, while phosphorescence was everywhere observed, no explanation on scientific principles was attempted, until in 1675 Nicolas Lémery, in a paper on the preparation of solar phosphorus, stated that the light produced was the result of *rapid molecular motion*; thus accepting the doctrine foreshadowed by Huygens and Euler, in opposition to the emission or corpuscular theory of Newton. These prophetic utterances, however, of the present undulatory theory of light were not recognized; it was reserved for later experiment to demonstrate the truth of this intuitive perception.

The "persistence of force" and the "indestructibility of matter" must first be proved, before it could be shown that the phenomena of phosphorescence are due to the same causes as the light evolved by electrical discharge, chemical combination, or mechanical movement. If, as Dr. Young has shown, light be motion or vibration of a luminiferous ether which fills space and permeates all bodies, the conditions of inexorable law are as fully met in the pale glimmer of luminous plants, the flash of the fire-fly, or the radiance of the glow-worm, as in the light evolved by the heavenly bodies.

The discovery of the luminosity of plants has been attributed to the daughter of Linnæus. In the year 1762, during the months of June and July, she observed radiations of light from a cluster of garden nasturtiums (*Tropæolum majus*), which occurred in the morning or evening twilight. The same effect has been observed in other flowering plants, but principally in those bearing orange-colored bloom, as the corolla of the sunflower, the French marigold, and in the yellow lily. Some species of African marigolds also have manifested this property. Professor Haggern observed the luminous radiations to be most brilliant in the marigold, next in the nasturtium, and, third, in the yellow lily. A careful microscopic examination convinced him that the light did not depend upon the presence of any animal organisms. The rapidity of the flash indicated electrical action, and upon analysis he found that the light proceeded from the petals, the anthers being at an appreciable distance. He supposed that in the process of fecundation the elasticity of the anthers scattered the pollen on the petals and produced electrical disturbance by the impingement of these different substances. In bog or marsh land plants, of the genus *Pandanus*, the rupture of the spathe or shield of the flowers is sometimes accompanied by a loud, cracking noise and a spark of light. In 1857 M. Fries perceived light emitted by a group of poppies (*Papaver orientale*) in the botanical garden at Upsal, to which he called the attention of numerous witnesses.

The phosphorescence discovered by the daughter of Linnæus bore the character of an electrical spark which shot out from the corolla and was discernible at the same hour upon warm evenings when the air was surcharged with electricity. The radiance noticed by M. Fries also indicated a periodicity of movement, occurring always when the air was electrical, between ten and eleven o'clock at night. Not only the blossoms but the leaves of many of the flowering plants have been observed to emit a phosphoric light under favorable conditions of the air—even the milky juice of several vegetables becomes luminous in the dark; this was particularly noticed by M. Martins in a species of the phosphorescent spurge (*Euphorbia*).

The *giving out of heat* in the blossoming of plants was discovered by Lamarck more than a century ago in the European arum, which in opening "grows hot as if about to burn." It was afterward observed by De Saussure, and by the later appliance of the thermo-multiplieo the heat *generated* in any cluster of blossoms is made appreciable. The development of this force is most remarkable in tropical plants, where a large number of flowers are crowded together under a covering hood of spathe. The temperature increases periodically, growing greater in the afternoon and appearing like a "paroxysm of fever" which passes off with the decline of day—the greatest intensity always occurring *during the shedding of the pollen.* Any great increase of temperature is necessarily prevented by the equalizing effect of evaporation from the expanded surfaces of the leaves, and the water which pervades all the substances. It is only during a period of unusual energy, as in blossoming, that the heat becomes apparent.

The light and heat set free by combustion we recognize as merely the expression of chemical change and a giving back to original elements the forces that were stored up by vegetative activity in the coal-beds of the past or in the woody fibers of later growth. In the mysterious circle of Nature's means and mechanism, light, heat, and chemical combination are alternately cause and effect—not, it is true, in the abstract sense of cause, but, being mutually convertible or co-relative, maintain necessarily reciprocal action. Now, the fact that they are thus reactive and interchangeable as *modes of motion* offers a very simple explanation of the giving out of light by plants at a moment when the *surplus amount* of these garnered forces is thrown off during the vital processes of reproduction.

That increased chemical activity exists at the period of flowering is shown by the exhalation of an unusual amount of carbonic acid, and this increased action supplies the additional heat for the elaboration of the reproductive agents, whose preparation seems to be the highest expression of energy in vegetable organization. Some doubt exists as to the proximate cause of the manifestation of light by flowerless or cryptogamic plants, in which are embraced the mosses, fungi, etc. A study of the conditions under which it is presented will, I think, enable us to refer it directly to similar chemical action.

These plants were ingeniously named by Linnæus because the concealed organs of reproduction offer great diversity in structural relations—a diversity so great that they can not even be presented under one common type; we must, therefore, look for modifications in the expression of force directed by these different forms. The root-hairs which form in the germination of one of the liverworts (*Hepaticæ*) have been observed to be luminous in the dim light of caverns. It gathers principally upon schists, and derives its name (*Schistostega Osmundacæ*) from a miniature resemblance to the royal fern *Osmunda.* This plant, like the true cavern-mosses, is emerald-green, and develops into root, stem, and leaf. The dainty fern-like leaves or fronds are of the very simplest organization, and a slender, thread-like stem rises from the apex, bearing upon its summit a valvular case or capsule which contains the reproductive cells or sporules. The root-hairs which give out the light appear like the tangled meshes of a spider's web; and, as the same effect has been noticed in these tenuous structures, some naturalists have attributed the appearance to reflected light. But analogy in the condition of this and other light-emitting plants leads to the conclusion that it is self-luminous.

The phosphorescence of fungi has been observed in various portions of the world. Rumphius first noticed its appearance in Amboyna in a species of corticium to which the name *Telephora cærulum* was given. Under this specific name are grouped many minute forms of fungi, only the mycelium of which were known to Linnæus and Agardh, the discovery of other organs forming the complete plant being of more recent date.

Among mushrooms four of the genus *Agaricus* are luminous, and have been examined with special reference to this effect by Delille, Fabre, and Tulasne: The red or orange-colored species (*Agaricus olearius*), inhabiting the adjacent soil or roots of olive-trees in Central Europe; the fire-mushroom, or *Agaricus igneus*, which Rumphius discovered in Amboyna; the *Agaricus noctilucus*, found at Manila by Gandichaud; and *Agaricus Gardineri* of the Brazilian provinces, growing upon the dead leaves of the Pindoba-palm. The red mushroom of the olive-trees is wonderfully beautiful. The gills curve out from the pedicle and expand under the pileus into a trumpet- or bell-like form of almost vermilion hue, which changes at night into a pale-blue light, gleaming, where they are massed together, like blue bells of fire.

M. de Candolle erroneously supposed that the phosphorescence of the *Agaricus* of the olive occurred only at the time of its decomposition. M. Fries, with equal error, attributed the effect to the presence of a secondary parasite; Tulasne, however, denies that the seat of light is in the mold, and states that he has observed the phosphorescence of the plant itself. He agrees with Delille in regarding the appearance as limited to the period of growth, and refers to it as a "manifestation of vegetation." M. Delille supposed the radiance to be intermittent, while M. Fabre observed that exposure to the sunlight appeared to have no influence whatever upon the phenomena, and that the light was exhibited at any time under cover of darkness. Dr. Phipson, in reviewing M. Fabre, remarks that this seems, however, to indicate that the light of the sun has in reality an influence upon the emission of light during the daytime, and that the phenomenon is probably a case of phosphorescence after insolation. But as we know the *Agaricus* belongs to that class of colored parasites which are destitute of green foliage, and consequently of proper digestive organs of their own, and draw support from the elaborated products of the foster-plant, the phosphorescence may be accounted for as the result of chemical action under conditions where the influence of solar light is not required to produce a higher combination.

Tulasne recognized that the light was not confined exclusively to the reproductive surfaces, and proved by dissection that the whole mass offered scintillations. This is probably due to a sympathetic or highly vitalized condition of the whole plant during the process of fecundation, as is indicated by the juice of the phosphorescent euphorbia. The light, however, is usually emitted by the organs of reproduction; this is particularly the case in young fungi, while, in the older ones, after the luminosity has disappeared from the gills, the surface of the stipe becomes radiant.

The mycelium of the root-shaped fungi (rhizomorpha) penetrates through the decaying organic matter of wood and coal deposits, exhibiting a clear pale light. This has been particularly observed in the mines near Dresden, Hesse, and occasionally in England. These flowerless, gleaming plants impart a weird beauty to the caverns of granitic rock in Bohemia, illuminating them with a pale mimicry of moonlight.

The most remarkable instances of cryptogamic phosphorescence have been noted by Mr. Gardner in Brazil, by Dr. Cuthbert-Collingwood in Borneo, by Mr. Hugh Low and James Drummond in Australia, and by Mr. Worthington-Smith in the Cardiff coal-mines. Rev. J. M. Berkeley cites an instance in England, where a dazzling radiance was observed upon a spruce or larch log, which continued for several days—a byssoid mycelium, yielding an unusually pungent odor, being recognized. The common potato also, in decomposing, generates a peculiarly luminous parasite; and, at one time, an alarm of fire was sounded in the streets of Strasburg from the light produced by a decaying mass stored in a cellar. An instance has recently come to my notice, where a brilliant light was thrown off by pieces of cantaloupe, after a few hours' exposure to the air.

Wherever, then, we encounter decomposing vegetable matter, we observe some form of fungi living upon and appropriating the changed substances of a former condition to the generation of a new life. What, therefore, seems to us a loss or waste, is merely change—change of form, change of condition. The absorbing roots of these parasites grow into the tissues of the host in the most intimate manner, deriving from a disorganization of the substances the elements necessary to their own being.

Vergil describes the blighting mildew on the grain as "an unbidden crew of graceless guests that choke the fields"; and De Barry writes that there is a frequent unbidden guest in every household, who lays under contribution its stores of sweets. The mold or mildew which gathers on the surface of preserves is a plant of exquisite beauty when viewed with low magnifying power and by reflected light, for what appears to the naked eye only a soft, white, woolly crust, becomes a glittering forest of graceful stems and branches, standing like fine-spun silver upon the dark background of the supporting surface. This substratum is in reality a mycelium, or system of fine interlacing, thread-like roots, which form the vegetative part of the plant, and are woven into a soft, black or brown velvety substance, through which run russet, scaly hairs. The branches rise to about the fiftieth of an inch, and bear the fruit and seed-cells. Higher microscopic power reveals the spores which are the analogues of seed, although they possess neither their vestments nor organs, but are simple membranous sacs (full of liquid), which germinate at some indefinite point of their convex surface into a new plant like that which produced them.

A comparison of the condition of flowering plants and of the mosses and fungi, during a phosphorescent display, will lead us to attribute the appearance to similar action of vital forces, if we for a moment review the processes by which these forces are accumulated. In the growth of plants heat acts as a dynamic agent, which the germ of the plant directs and uses. The first action of growth consists in the conversion of the starch of the seed into a soluble form, and in chemically combining the starch, sugar, oil, and albumen by fermentation into the protoplasmic matter which supplies the material for the tissues of the plant. The development of this protoplasm into organized tissue is due to the inherent power of the germ, and marks the second stage of progress. The only action of light is employed in producing higher chemical combination; heat acts as the constructive power.

The process of growth does not absorb all the elaborated materials provided, and an additional amount of heat or force is generated by the decomposition or a "retrograde transformation" of these compounds. A much greater proportion, however, of the organized substances is stored up within the structure of the plant as a "reservoir of reserved material," to meet the exhaustive process of flowering and the maturing of fruit and seed. That these processes are sustained at the expense of an extra amount of force, and by the decomposition of their own products, is evident from the unusual production of carbonic acid. The combination of carbon, oxygen, and hydrogen, in the building up of plants, is here reversed, and by a retrograde process heat is set free, which we have seen is necessary for the elaboration of reproductive agents.

This appears to be precisely the same action which takes place in the reproduction of fungoid plants and mosses. A corresponding condition is shown by the rapid exhalation of carbonic acid; indeed, Dr. Carpenter asserts that a decomposition of a portion of the absorbed material is the only conceivable source of the large quantity they are constantly giving out, and ascribes the very rapid growth of these plants to a "retrograde metamorphosis." The substances which enter into the new growth are already prepared by the foster-plant, and we find the parasite incapable of forming any new combination through the agency of light. This necessarily awakens a doubt of any action resulting from insolation or reflection in the cases of the liverworts or mushrooms which have been referred to.

The expression of light in flowering plants seems to be through the medium of electricity, while in cryptogams it resembles the steady glow of slow combustion. High microscopic power may, however, reveal, as in some cases of animal phosphorescence, the sparkle and flash of rapid and minute scintillations. Inquiry in this direction, I think, has never been made; nor is an analysis necessary for our present purpose. For, if we regard the light either as the result of slow combustion, or catch the vivid flash of the electric spark in this reproduction (itself the product of decay), we are met by the same inexorable permanent law, that there is not a leaf that rots by the roadside, nor a spear of pale club-moss, that is not in itself a reservoir of recreative power throwing back its faint, pulsing light or its equivalent of heat into that quickening flood which the great heart of Nature sends down through the illimitable and unknown.

CROLL'S "CLIMATE AND TIME."*

By W. J. McGEE.

THE recent publication in "The Popular Science Monthly" of a paper on "The Age of Ice," and its apparently favorable reception and republication elsewhere, prompt the writer to submit the following incomplete notice of a work in which the field barely entered by the author of that paper is most thoroughly and exhaustively examined.

In addition to a convenient abstract of the line of argument pursued, and a statement of some fundamental principles of geology, it is pointed out in an introductory chapter that the earlier theories framed to account for climatal variations during the geological æons are utterly inadequate ; that the earth could not pass through hotter or colder portions of space without seriously deranging the mechanism of the solar system ; that a diminution of heat from this or any other cause could never inaugurate a glacial epoch ; that considerable changes in the obliquity of the ecliptic have never occurred, and could not have caused glacial periods if they had ; and, finally, here as well as in a more recently published paper,† which may be considered as supplementary to this chapter, that material changes in the position of the terrestrial axis can never have taken place : in short, he shows, by bringing together the independent results arrived at by eminent geologists, physicists, and mathematicians, that the various cataclysmic theories of geological climate are alike untenable. Telluric causes being thus shown to be incompetent, no alternative remains but to

* Climate and Time in their Geological Relations: A Theory of Secular Changes of the Earth's Climate. By James Croll, LL. D., F. R. S., etc., of Her Majesty's Geological Survey of Scotland. American edition, 12mo, pp. xvi.–577, with Plates. New York: D. Appleton & Co., 1875.

† "Geological Magazine," September, 1878.

seek for the cause of secular climatal variations in the earth's astronomical relations. In the same chapter, but more fully in the Appendix, Dr. Croll goes on to show that the variable length of the seasons consequent upon the ellipticity of the terrestrial orbit had begun to attract attention before the close of the last century; and that, as early as 1830, Sir Charles Lyell had expressed the idea that the long winters and short summers of the southern hemisphere might have some influence in lowering the temperature of that portion of the globe.* Sir John Herschel and others, however, soon after demonstrated that the light and heat received by any portion of the earth's surface during any year is practically invariable, whatever the eccentricity of the terrestrial orbit; the greater proportionate length of winter in the hemisphere whose winters occur in aphelion being exactly counterbalanced by the greater proximity of the sun in summer. This is, indeed, a legitimate deduction from Kepler's second law, and was long ago demonstrated by D'Alembert. The hypothesis, therefore, fell into disrepute. Over fifteen years ago, however, the author of the work under consideration began to point out, in a series of papers (chiefly in the "London and Edinburgh Philosophical Magazine"), the substance of which is reproduced in "Climate and Time," that while the variable length of the seasons resulting from this cause could never produce a glacial epoch *directly*, yet the same cause might, especially when intensified by a high degree of eccentricity, bring into operation a chain of physical agencies which could not fail to very materially affect the climate of the globe.

As a further introduction to that portion of the work devoted to the elucidation and application of the above-named astronomical and physical principles, and as an illustration of the efficiency of one of the secondary agencies on the operation of which the theory is based, the heat-conveying power of ocean-currents is discussed at length in the second and third chapters. The importance of these currents is shown to be immense. Thus, according to Professor Dove's "Temperature Tables," the temperature of the British Isles, and of western Europe generally, is 12° Fahr. above the normal—or, more properly, the mean—for that latitude, while the temperature of corresponding portions of eastern North America is nearly as much below the normal. Dr. Croll attributes this difference to the effect of the Gulf Stream in warming western Europe, and of the cold counter-current in chilling our American coasts. The same subject is recurred to frequently throughout the volume, notably in Chapters XI. and XII., in the latter of which Mr. Findlay's objections are answered by calculating from his own data that the heat liberated from the Gulf Stream in the North Atlantic is equal to more than one half of that received directly from the sun in the same latitude. An analogous condition of things exists on the shores of the North Pacific, which are similarly

* "Principles," first edition, 1830, vol. i., p. 110.

affected by the Kuro Siwo; though there the effect is less distinctly marked, owing to the more unfavorable conformation of the coast. So effective are ocean-currents in distributing the heat of tropical and the cold of polar regions, that our author concludes that the globe would not be habitable for existing orders of beings were their influence to cease.

The heat-conveying power of aërial currents is also discussed; but it seems possible that Dr. Croll has under-estimated their capacity, many times increased as it is by the aqueous vapor with which they are laden. Space will not, however, permit the discussion of this interesting point.

The combined effect of aërial and aqueous currents is estimated to reduce the difference in temperature between equator and poles from 218° to 80°. This astonishing result may be substantially verified by a simpler and probably more accurate method than that employed by Dr. Croll. Meech shows * that the relative solar intensity at the equator, at the poles, and over the whole earth, varies in the ratio of 81·50, 33·83, and 66·73, respectively; and Dove, many years ago, determined the mean annual temperature of the earth to be approximately 58°. Now, the solar energy elevates the temperature of the earth from that of stellar space, or −239° (as determined by Herschel and Pouillet), to +58°. 297° is, therefore, the mean elevation of the earth's temperature by solar action. Eliminating the distributing power of aërial and aqueous currents, and assuming the present mean relation between absorption and radiation to remain constant, it is quite probable that the temperature of the various parts of the earth's surface would vary directly as the solar intensity. A simple proportion, then, shows us that while the equator would be raised 363°, or to +124° of absolute temperature, the poles would be elevated only 150°, or to −88°; making a difference of 212° between equator and poles. If, as is extremely probable, the temperature of stellar space is really below −239°, this difference would be still greater. Moreover, it can be shown that any decrease in temperature tends to increase the radiating capacity of the earth by rendering the surrounding atmosphere diathermous. Hence the poles would sink lower in temperature, proportionally, than the equator.

Six chapters (VI.–XI.) are devoted to the "gravitation theory" of oceanic circulation, with the object of completely refuting it. Two reasons for the very full discussion of this branch of the subject are given: 1. Because the gravitation theory "lies at the root of a great deal of the confusion and misconception which have prevailed in regard to the whole subject of ocean-currents"; and, 2. Because, "if the theory is correct, it militates strongly against the physical theory of secular changes of climate advanced in this volume." The advo-

* "Relative Intensity of the Sun's Light and Heat," "Smithsonian Contributions," vol. ix.

cates of this theory are separated into two arbitrary classes: 1. Those who consider the difference in density between equatorial and polar waters to be due to difference in saltness; and, 2. Those who attribute the difference in density to difference in temperature. Lieutenant Maury's theory, stated in his "Physical Geography of the Sea," is rejected because that eminent meteorologist recognized both of the above-named causes of difference in density, while they are very nearly equal and quite antagonistic, and because the actual differences in specific gravity due to these causes are mathematically demonstrable to be incompetent to produce so powerful currents; being, in fact, as Dr. Croll pointedly insists, only one seventh of that necessary to produce the slightest motion. Dr. Carpenter's theory, based chiefly on differences of density due to differences in temperature, is discussed at still greater length than Lieutenant Maury's, and is rejected on the grounds—1. Of being counteracted by differences in saltness (in which view Dr. Croll has the support of Sir Wyville Thomson); and, 2. Of resting on assumed causes utterly inadequate either (*a*) to produce existing currents, or (*b*) to convey northward so great an amount of heat as that shown to be given out by the Gulf Stream; the apparently paradoxical conclusion, that the Gulf Stream actually conveys an absolutely greater quantity of heat to high latitudes than the whole Atlantic could convey, being explained by the proposition that the Gulf Stream obtains the greater portion of its heat in the southern hemisphere, while according to Dr. Carpenter's hypothesis the circulation should be independent in each hemisphere.

In Chapter XIII. the "wind theory" of oceanic circulation is enunciated and elaborated, and in the succeeding chapter its relations to climatal variations are discussed. It is first pointed out that the various ocean-currents are not due to the trade-winds alone, as was until recently supposed by advocates of the wind theory, but to the general impulse of the prevailing winds of the globe, viewed as a single grand system, and acting, not upon several separate and independent oceans, but upon a single grand oceanic system, the various parts of which are most intimately related. The correspondence between the supposed cause and the observed effect seems to be all that could be desired. "All the principal currents of the globe are in fact moving in the exact direction in which they ought to move, assuming the winds to be the sole impelling cause. In short, so perfect is the agreement between the two systems, that, given the system of winds and the conformation of sea and land, and . . . the system of oceanic circulation might be determined *a priori*. Or, given the system of the ocean-currents, together with the conformation of sea and land; and the direction of the prevailing winds could also be determined *a priori*. Or, thirdly, given the system of winds and the system of currents, and the conformation of sea and land might be roughly determined." Return currents are formed through the tendency of the ocean to maintain its level, and naturally select the path of least resistance. Hence they are usually undercurrents.

The general agreement between the systems of winds and of oceanic circulation is shown on a chart. It may be mentioned that the direction of the winds, as laid down on this chart, does not precisely correspond with the direction determined by the late Professor Coffin, and indicated on the charts in his cyclopean work, "The Winds of the Globe," recently published by the Smithsonian Institution; and it is quite probable that more exhaustive observations will show that there are inaccuracies of as great magnitude in the representation of oceanic currents. It should be borne in mind, however, that any minor discrepancies between the two systems do not militate against the theory, unless it can be shown that they are not such as would be produced by the conformation of the coasts; for the wind system, as a cause of oceanic circulation, is modified by this important and frequently antagonistic factor.

In seeking for demonstrative evidence of the correctness of the wind theory, Dr. Croll seems to fall into an error which he has repeatedly had occasion to point out in others. Thus, in discussing one of Dr. Carpenter's sections, he shows, from Professor Muncke's coefficients of the density of sea-water, at various temperatures, that the surface of the Atlantic is, at north latitude 23° 10′, two feet six inches, and at north latitude 37° 54′, fully three feet six inches higher than at the equator, on account of the greater thickness at these points of the upper layer of warm water. It is urged that "gravitation never could have caused the ocean to assume this form," and hence that "gravitation can no more cause the surface-water of the Atlantic to flow toward the Arctic regions than it can compel the waters of the Gulf of Mexico up the Mississippi into the Missouri." Now, by Dr. Croll's own showing, it is gravity alone that causes the surface of the Atlantic to assume that form—that is, if that form is actually assumed; a fact not determined by measurements. It is merely calculated from the data given to what height above the level at the equator the waters of the North Atlantic would have to be raised in order to maintain a condition of static equilibrium; it is not shown that the waters are so elevated, but only that they would have to be in order that the influence of gravitation, in producing oceanic currents, should be eliminated. How the warm water, on which this supposed configuration depends, was conveyed thither, is a dynamical and not a statical problem.

Moreover, two important elements in the problem of oceanic circulation are disregarded by Dr. Croll: 1. The water borne from equatorial to polar regions by aërial currents, in the form of aqueous vapor, must exercise a powerful influence not only on the earth's temperature but also upon marine currents; for, as shown by Lieutenant Maury, it is sufficient to permanently render the Arctic seas much less saline than those of tropical regions. Sir Wyville Thomson strongly insisted upon the importance of this agency in his presidential address before the geographical section of the British Association, at its Dublin meeting, in which he even went so far as to maintain that one part of the general oceanic circulation takes place through the atmosphere; though in thus considering the aërial circulation to be telluric, or universal over the whole surface of the earth, instead of hemispheric, or comparatively independent on opposite sides of the equator, this distinguished explorer seems to assume to be true that which is most emphatically contradicted, not only by the almost innumerable observations collated by Professor Coffin in the great work already referred to, but by those of all other observers. It is true, though, that, as the transportation of the vapor is accomplished by aërial currents, these currents *indirectly* cause those marine currents formed by the precipitation of vapor. 2. The earth's axial rotation, which is one of the two great causes of aërial circulation, must exercise considerable effect on the marine currents, though of course its operation is more seriously interfered with by the inequalities of the terrestrial surface in the case of the earth's discontinuous liquid envelope, than in the universal gaseous one. Still, if, as suggested by Guilleman, this force is adequate to influence the course of rivers flowing to the north or south, it will vitiate any theory which neglects it. Moreover, the actual effect of the earth's axial rotation would be very likely to elude observation, as the currents so produced would necessarily correspond approximately with the principal aërial currents of the globe; and hence the combined effect of the two causes would be likely to be attributed to the most obvious one. The influence of axial rotation on the oceanic circulation may be determined mathematically, however, and indeed such an investigation has already been entered upon by Mr. Ferrel; but his results are not generally known.

While both branches of the gravitation theory are summarily dealt with, analogy with the second prime cause of aërial circulation (i. e., difference in density, owing to differences in temperature and humidity) would indicate that any difference in density, whether due to difference in temperature or in saltness, would be sure to play a minor part in the phenomenon of oceanic circulation, at least in some cases. Therefore, of the five distinct agencies which probably coöperate in disturbing the equilibrium of the ocean, Dr. Croll recognizes but one; and, singularly, in view of his usual method, he nowhere endeavors to prove mathematically, or in any other conclusive manner, that the impulse of the winds is adequate to produce the effects attributed to it. The wind theory can not, therefore, be said to be demonstrated. Nevertheless, the agreement between the winds and the marine currents is so striking that geographers and navigators are generally disposed to adopt that theory. The late distinguished geographer of Gotha, Dr. Petermann, was one of the most prominent advocates of the theory.

With Dr. Croll's connection with this subject a new era may be said to have been inaugurated. Previously it had been deemed sufficient to point out certain agencies which *seemed* to be adequate to produce the observed effect, without making any effort to show mathematically that they *were* adequate; but this physicist contended from the first that cause and effect should be determined in *absolute measure*, just as in the other branches of physical science. His failure to observe this excellent rule in one case is to be attributed to the same paucity of trustworthy observations which is the occasion of the obscurity enveloping the whole subject.

In Chapter IV. the physical agencies leading to changes of climate are discussed, and an explanation of the present low temperature of the southern hemisphere is offered in Chapter V. As has already been intimated, that hemisphere, which has its winters in aphelion, has a longer winter and a shorter summer than the mean. Now, it is perfectly obvious that this variation in the length of the seasons increases with any increase in the eccentricity of the terrestrial orbit, and similarly diminishes with any diminution of eccentricity; for the eccentricity of the planetary orbits may vary within pretty wide limits, which have been determined by La Grange, Leverrier, and, more recently as well as more satisfactorily, by Mr. J. N. Stockwell, of Cleveland. The present eccentricity (0·0168) is such that there is a difference of about eight days in the length of summer and winter in either hemisphere, when the solstices coincide with the apsides; and, the winter solstice of the southern hemisphere being now not far from aphelion, that hemisphere has the long winter and short summer. It is admitted, however (even too readily, it would seem), that the present degree of eccentricity is too insignificant to exercise much influence on the climate of the globe; but 210,000 years ago, when, according to Dr. Croll's elaborate computations, the eccentricity was 0·0575, the excess of winter over summer, due to this cause, amounted to 26·7 days; and 850,000 years ago, the eccentricity then being 0·0747, it amounted to 34·7 days; and it is argued that so great a difference in the relative length of the seasons would indirectly, through the intervention of a number of physical agencies, materially affect the earth's climate. These agencies are shown to be such as would be brought into operation by an increase in the length of winter, even if its severity was not increased; and they are mainly dependent on the increased proportion of moisture precipitated as snow instead of rain. Of course, this snow would remain until melted by approaching summer, just as it does in every region where much snow falls.

"There are three separate ways whereby accumulated masses of snow and ice tend to lower the summer temperature": 1. By means of direct radiation [and by direct contact]; 2. By direct reflection back into space of the solar rays; and, 3. By chilling the air and condensing the vapor into thick fogs which intercept the solar rays. This third influence had better not be insisted upon, however, as it is counteracted by—1. The immense amount of latent heat liberated in the condensation of the vapor ; and, 2. The interception by these fogs of the heat radiated from the earth. A substitute may be offered for it, viz., by rendering the atmosphere diathermous, and therefore incapable of absorbing the solar rays or of intercepting the radiation and reflection from the earth. In consequence of the operation of these agencies, the air in snow-covered regions seldom rises above the freezing-point, and the solar heat is conveyed away into space and utterly lost to the earth ; for, if a portion of it is absorbed by the snow and ice during the hours of sunshine, it is not rendered sensible, owing to the high latent and specific heat of these forms of water, and is radiated away, unchecked by any "protecting blanket of vapor" (which Professor Tyndall shows to be so efficacious in protecting the earth from radiation, but which can not exist above snow-covered regions), during the succeeding hours of darkness.

This *waste* of solar energy, in turn, still further curtails the already short summer, and permits the same causes to operate with increased efficiency during the succeeding season. Moreover, the reaction of each effect upon its cause is such as to strengthen the cause, and the interaction of all the agencies is such as to increase the efficiency of each. Each winter would thus add to the snow which had remained unmelted during the intervening summer, until the accumulation of snow was checked by the absence of vapor for condensation and precipitation ; for, as pointed out by Tyndall, the presence of large quantities of vapor is the first essential for the formation of extensive glaciers.

It has been objected to the theory, that this picture has been overdrawn—that no such slight cause could so seriously disturb the equilibrium of the seasons ; it has even been shown mathematically that the heat of a few days in summer would melt the total accumulation of the previous winter. The answer to these objections is, that in such calculation the operation of the agencies just described was disregarded, and hence that its results are unreliable ; that, though the solar intensity is greater over polar regions in summer than in the tropics, as shown by Meech, it is not sufficient to melt the annual accumulation of ice, else this ice never could have accumulated to so vast an extent as to annually send forth thousands of colossal bergs to be melted in temperate seas ; that not only in the Alps, but even in the almost tropical Himalayas, where the sun shines with undiminished intensity throughout the year, the direct effect of the solar energy is so far below the accumulation of congealed vapor that the ice is only prevented from piling up indefinitely by that property which enables it to flow down to lower levels where the conditions described do not exist ; that even in the northern portions of our own country the slight annual film of snow retards the coming of summer by weeks if not months ;

that while the reception and dissipation of heat by any portion of the earth's surface are equal, the physical properties of ice are such that ice-covered regions lose their heat *immediately* without being sensibly increased in temperature. The effect on temperature of accumulations of ice and snow must, therefore, be enormous. "Were it not for the ice," strikingly remarks Dr. Croll, "the summers of Greenland . . . would be as warm as those of England; but, instead of this, the Greenland summers are colder than our winters. Cover India with an ice-sheet, and its summers would be colder than those of England." Even on our own coasts the grounding of a single berg appreciably lowers the temperature and greatly increases the danger of frosts.

On the hemisphere whose *summers* occurred in aphelion during the period of high eccentricity, an exactly opposite tendency would be manifested: the snow and ice would gradually melt and perhaps entirely disappear, and vegetation might flourish even under the pole. That hemisphere would then enjoy an *interglacial* period. These periods occupy an important place in the theory under examination.

Dr. Croll then proceeds to show how the accumulation of ice in polar regions would affect the general oceanic circulation: "Owing to the difference between the temperature of the equator and the poles there is a constant flow of air from the poles to the equator. It is to this that the trade-winds owe their existence. Now, as the strength of these winds, as a general rule, will depend on the difference of temperature that may exist between the equator and higher latitudes, it follows that the trades on the cold hemisphere will be stronger than those on the warm. . . . Suppose, now, the northern hemisphere to be the cold one. The northeast trade-winds of this hemisphere will far exceed in strength the southeast trade-winds of the southern hemisphere. The *median-line* between the trades will consequently lie to a very considerable distance to the south of the equator. . . . Let us now consider how this would affect the Gulf Stream. The South American Continent is shaped somewhat in the form of a triangle, with one of its angular corners, called Cape St. Roque, pointing eastward. The equatorial current of the Atlantic impinges against this corner, but, as the greater portion of the current lies a little to the north of the corner, it flows westward into the Gulf of Mexico and forms the Gulf Stream. . . . Now, it is perfectly obvious that the shifting of the equatorial current of the Atlantic only a few degrees to the south of its present position—a thing which would certainly take place under the conditions we have been detailing—would turn the entire current" to the south of Cape St. Roque, and thence along the Brazilian shores and into the Southern Ocean, and "the Gulf Stream would consequently be stopped."

Now, it is quite manifest that if the wind theory of oceanic circulation is incorrect—and, as already shown, its correctness has not been demonstrated—no such deflection of the Atlantic current would be likely to occur. This possibility is fairly confronted by Dr. Croll when he admits that the gravitation theory "militates strongly" against his theory of secular changes of climate. But there is another self-evident proposition which seems to have escaped his attention. Assuming that the results detailed above follow in the order laid down when the eccentricity is at a high value, it is perfectly manifest that *the deflection of the Gulf-Stream feeder is an effect of glaciation*, and, if a cause at all, only a secondary one. Hence, if the purely physical agencies *alone* are capable of causing glaciation, Dr. Croll's theory of secular changes in climate will stand, whether or not the wind theory of oceanic circulation is correct; but, if they are *not* capable of producing a glacial period *alone*, the theory will fall, even if the wind theory of oceanic circulation be correct. This can not be too strongly emphasized. Yet, not only in "Climate and Time," but in his other publications on the subject, Dr. Croll dwells upon the deflection of ocean-currents as the principal telluric element in his theory!

The only positive evidence adduced to prove that the Gulf Stream was deflected during the glacial period is the fact, pointed out by Mr. Crosskey, that there is more difference between the glacial and recent shells of Scotland than between the glacial and recent shells of Canada. But this only proves that the present temperature of that part of Canada is lower than that of Scotland; for the temperature of the waters at the edge of the ice-sheet must have been approximately the same, whatever the latitude to which it extended. This evidence is, therefore, utterly valueless. Furthermore, we have pretty reliable positive evidence that the Gulf Stream was not stopped during the glacial epoch, in the more northerly limits of continental glaciation in those parts of Europe so greatly affected by the Gulf Stream to-day, any more than in the United States, where its influence is comparatively unfelt. Moreover, Professor Dana has shown in his "Journal" that the distribution of ice during the glacial period coincided in a general way with the present distribution of rainfall in the same latitudes. Now, the greater part of the moisture of the United States, especially of the great Mississippi Basin, is derived from the Gulf of Mexico; and the stoppage of the South Atlantic feeder of the Gulf Stream would cool the waters of the Gulf so considerably as to materially diminish our vapor-supply, and at the same time the distribution would be altered. Similarly, the stoppage of that current during the glacial period would have so altered the distribution that its relation to the present precipitation would not be recognizable, even if it did not so completely cut off the vapor-supply as to prevent glaciation. The mass of evidence is therefore against the hypothesis of the shifting of this important marine current during the glacial period; and, as this would, as Dr. Croll points out, be likely to be the first out of all of the ocean-currents to be deflected, it may reasonably be doubted whether any were seriously affected by the cause specified. It must be admitted, however, that the physical agencies which have already been described seem competent to inaugurate a glacial epoch during any period of high eccentricity of the terrestrial orbit, without any assistance from the meteorological influences. These periods, recurring at long and irregular intervals, must have alternately refrigerated and revivified the circumpolar regions again and again during the immeasurable ages whose lapse is so dimly recorded in the rocky strata. The theory is, therefore, in the highest accord with the modern uniformitarian doctrine which rejects all hypothetical explanations of phenomena which are not in harmony with the present course of nature.

The present low temperature of the southern hemisphere as compared with the northern is explained by the assertion that the warm waters of the southern hemisphere are borne into the northern, while the cold waters of the northern hemisphere are conveyed into the southern. The argument supporting this conclusion is that of a radical advocate of the wind theory, and is as strongly opposed to the first principles of the physical theory of climate as the most conservative critic could wish. Space will not permit the discussion of this chapter.

Chapter XVIII. contains a *résumé* of the evidence of former glacial eras which had been collected up to the time of the preparation of the volume. There had already been placed on record more or less decisive evidence of former glaciers, not only in the Quaternary but in the Miocene, the Eocene, the Cretaceous, the Oölitic, the Permian, the Carboniferous, the Old Red Sandstone, the Silurian, and even the Cambrian. In some of these cases, notably in the formations of the Permian age, the evidence is so voluminous, so distinct, and from such widely separated localities, that it seems impossible not to conclude that our Pleistocene ice age was but the homologue of long antecedent secular winters. The reasons for the paucity of evidence regarding these early glacial eras are summarized in the preceding chapter.

A statement of the method of computing the eccentricity of the terrestrial orbit, elaborate tables (laboriously computed by the author, with the exception of about a dozen periods) showing the eccentricity for 3,000,000 years in the past and 1,000,000 years in the future, and conclusions as to the probable date of the glacial epoch, constitute Chapter XIX. It has since been pointed out, by an undoubted authority in such matters (Professor Newcomb), that Leverrier's formulæ, which were employed in making the computations embraced in the tables, are defective, and hence that the figures given are not rigidly correct; but for the present these minor inaccuracies may be disregarded. The dates given may, therefore, be assumed to be correct, though they are undoubtedly only approximations.

It has already been stated that periods of high eccentricity occurred 210,000 and 850,000 years ago, respectively. Sir Charles Lyell, the founder of the uniformitarian school of geology, was inclined to believe that it was the first of these periods that produced the glacial epoch. Guided by the rate and amount of post-glacial erosion, however, Dr. Croll concludes that it was the more recent period which corresponded with the Quaternary glacial epoch; but he suggests that the earlier period may have coincided with the Miocene glacier. He thinks that the glacial period of the Quaternary lasted from shortly before the last great maximum until about 80,000 years ago (when the eccentricity was 0·0398, corresponding to a difference of twenty-two days in the length of the seasons), or for about 160,000 years—including, of course, the alternating interglacial periods.

Aside from the strong inherent evidence of the approximate correctness of this determination of the date of the glacial epoch (any uncertainty being due to the imperfection of Leverrier's formulæ), there is an abundance of independent testimony leading to substantially the same conclusion. Many eminent geologists have calculated the duration of post-glacial time from various data—generally the rate and amount of erosion or deposition in stated localities—with results usually ranging from 100,000 to 300,000 years. The mean of several of the most reliable is a trifle less than 200,000 years. Now, while each of these results, when viewed singly, may properly be regarded, in the words of Sir John Lubbock, "not as a proof, but as a measure of antiquity," they may, when viewed collectively, justly be considered reliable within wide limits, and to *prove* that no less a period than 40,000 or 50,000 years can have elapsed since the retreat of the ice-sheet from temperate latitudes; and the time has now come when he who endeavors to fix a later date for that event, without showing why these estimates should be rejected, need not be astonished if his efforts only bring him into contempt. So great is the weight of this independent testimony, indeed, as to warrant the suggestion that the glacial epoch of the Quaternary did not extend down to the period of high eccentricity 80,000 years ago, as Dr. Croll intimates, but closed 160,000 or 170,000 years ago. This last maximum might, then, be represented by the Reindeer epoch of Europe, and possibly (if it may be permitted in this strongly reactionary age to suggest the bare possibility that the pioneers in the field of American archæology, Atwater, Morton, Squier, and their compeers, did not err most egregiously in their estimates of the antiquity of the earlier works of our prehistoric races) by the migration into Mexico and Central America of the mound-builders of the Mississippi Valley—a migration which might thus furnish a parallel with that southerly migration of the Pliocene mammalian fauna at the inception of the glacial period, to which the Indian geologists attribute the richness and variety of the Siwalik and related fossil fauna of the Orient. It might further be urged that, if the duration of the ice age were so great as Dr. Croll suggests, we would be likely to find more unequivocal evidence of the fact in structural variations in those species which survived the cataclysm.

Interglacial periods are treated of at considerable length in Chapters XV. and XVI.; and it is justly held that any theory which does not explain the occurrence of the plant-beds of the drift, as well as its bowlder clays, is unworthy of acceptance. The fossiliferous strata of the marine formations found in Arctic regions, as well as the whole series of fossiliferous deposits found in the drift, are referred to these brief periods of unusually mild climate; but this seems almost too radical. If the general series of marine deposits in the Arctic regions were as nearly unfossiliferous as are the sedimentary strata of tropical India, such an hypothesis would be a little more likely to find acceptance among geologists. The fact developed by Meech, that the polar regions ought to have a warmer summer than the equator, if the solar intensity is a fair criterion, would indicate that these regions should have only a temperate climate if the ice were removed and the summer's heat stored up in the earth; and so slight an additional quantity of heat would accomplish this in a few years that, in view of the known variability of the solar emission and of the terrestrial absorption, it seems quite unnecessary to attach so much importance to the interglacial periods in their relations to Arctic formations. That coal is an interglacial formation, as is suggested in Chapter XXVI., seems still less probable, chiefly because these periods are too short to admit of so great an accumulation of vegetable matter as is stored up in each coal-seam.

It is not improbable, indeed, especially if the marine currents were not seriously affected by the polar snows, that the greater part of each of these periods would be required to melt the ice which had accumulated during the preceding glacial period. It seems very doubtful, too, even if the melting of the ice took place with the greatest conceivable rapidity, whether terrestrial animals or plants would spread over the barren wastes of crude glacial *débris* so rapidly as to people so wide a zone in the brief period assigned. Some of the intercalated fossiliferous beds of the drift, too, are very rich in numbers as well as species of both animals and plants—the latter sometimes forming extensive deposits of lignite—which must have required an immense time for their development. It seems scarcely possible that these terrestrial deposits can be interglacial, in the sense in which Dr. Croll employs the term, though the aqueous deposits, containing fossil shells of marine and estuarine mollusks, may justly be so considered; for such animals would be likely to keep close to the margin of the ice-cap as it retreated. To explain the two principal divisions of the drift, which have been recognized over immense areas on both sides of the Atlantic, it seems equally reasonable to refer the uppermost to the last period of high eccentricity, and the lower to that which Sir Charles Lyell supposed to coincide with the glacial epoch; in fact, in support of this collocation, we have the striking coincidence that the ice extended some degrees farthest during the period of greatest eccentricity.

Besides, such a collocation affords a sufficient period for the development of the rich and characteristic fauna and flora of the forest-bed—a widespread fossiliferous and carbonaceous deposit that must represent a lapse of time of geological importance. The belief that any glacier would necessarily remove all the *débris* formed by an antecedent one—a belief which has done much to prevent the acceptance of theories of successive glaciation—is best shown to be fallacious by the unequivocal evidence that the ice of the last glacial epoch did pass over older deposits of unconsolidated materials without removing them. Some such evidence is cited by Dr. Croll in the last-named chapters.

Among the interesting cognate subjects taken up in the remaining eleven chapters of the work are—methods of measuring the rate of subaërial denudation, and of determining the mean thickness of the rocks of the globe ; the age and origin of the sun (which is an able effort to reconcile the existing disagreement between the geologist and the astronomer and physicist as to the age of the earth) ; the physical cause of continental submergence and emergence during the glacial period ; the influence of the obliquity of the ecliptic on terrestrial climate ; some glacial phenomena of Scotland and England ; and the physical cause of glacier-motion. Appendices and an index are added.

It has been the aim in the foregoing pages to convey a general idea of the nature and scope of the work under review, and at the same time to indicate those points which do not seem to be sustained ; and, as is natural in view of this double object, justice has not been done to the work as a whole. "Climate and Time" represents years of study and an almost incredible amount of conscientious labor by perhaps the most competent living man to deal with this obscure subject, which occupies a position intermediate between geology, physics, and astronomy, and requires a thorough knowledge of all of these branches of science for its adequate comprehension. As a geologist, Dr. Croll occupies an important and responsible position ; and, as an astronomer and physicist, his reputation in scientific circles is even more enviable. Owing to the confusion in which he found the subject, to the absence of reliable data, and perhaps to a rather radical disposition, he seems to have fallen into a few errors ; but, with some reservations, his ingenious theory has been received with much favor, and has been pretty widely adopted, especially on the other side of the Atlantic. Here, it is comparatively unknown, and, in too many cases, lack of acquaintance with the principles on which it is based has led to its being unfavorably regarded ; but even those who reject the theory would do well to familiarize themselves with its details before they undertake to investigate the subject anew.

A LIVING HONEYCOMB.

MUCH as has been written about the marvels of instinct, there are still discoveries of great interest to be made in this prolific field. Particularly in the domain of those insect Yankees, the ants, with their wonderful ingenuity and human-like manners and customs, there is room for extended observations.

Some lately discovered facts in relation to them are so curious and interesting that it may be advisable to give them greater publicity than they have yet obtained. Some of these facts have long been known to the world of science, but not to the public. Others are new discoveries. As a whole they form one of the most surprising chapters in the history of animal life and contrivance.

Varied as are the social habits of the ants, it is generally considered that social bees surpass them in one particular, namely, their mode of storing supplies of winter food, the storehouses of ant-food having no contrivance similar in ingenuity to the honeycomb, with its rich supply of the sweets of life.

But the truth is that certain tribes of ants are well aware of the value of nature's sweetmeats as articles of food, and have developed a mode of storing up their winter honey still more curious than that practiced by the bees. They possess, in fact, what may be called living honeycombs; perambulatory cells filled with distilled sweetness. We refer to the honey-bearing ants of New Mexico, concerning which some very interesting facts have been brought to light during the past summer.

The Rev. Dr. McCook, of Philadelphia, a noted observer of ants and ant-life, has been interviewing these honey-bearers, and his results differ so widely from the ordinary facts of insect instinct that they can not but prove of general interest. These ants had been previously known only in New Mexico, but he discovered them in Colorado, inhabiting the locality known as the "Garden of the Gods," their nests being excavated in the stony crests of low ridges which run through this mountain-girt paradise.

The ridges are composed of a friable sandstone, into which our minute masons mine deeply, digging galleries which sometimes run for several feet into the rock. The nest, outwardly, is some ten inches in diameter by from two to three and a half inches in height, composed of sand and bits of stone carried from within, some of which seem large enough to defy a regiment of ants to move them.

Inside the nests successive chambers are excavated, connected by galleries, the floors of the chambers being comparatively smooth, while the ceilings are left in a rough state. But this roughness is no evidence of carelessness in the builder. It has, on the contrary, an important object: this is to furnish foothold for the clinging feet of certain extraordinary-looking creatures, which form the living honeycombs of which we have spoken.

Fancy an animal with the head and thorax of a small ant, but with all the posterior portion of the body converted into a round sac, of the size of a large pea, and of a rich translucent amber hue—it being, in fact, distended into a reservoir of honey. This honey-bag is immense when compared with the size of the ant, the unchanged parts of which might pass for a black pin's head attached to the side of a marrowfat pea. These odd-looking creatures cling to the roof of the chamber with their feet, the distended honey-bag hanging downward like an amber globe. On seeing them we instinctively imagine that their leg-muscles must be developed in a fashion to put to shame those of human athletes, since it is no light weight which they are thus forced to continuously support.

In each chamber of the nest about thirty honey-bearers are found, making some three hundred to the complete nest. Besides these there are hundreds or thousands of others, workers and soldiers, lords and queens, to whom the honey-bearers serve as storehouses of winter food.

Dr. McCook succeeded in bringing some of these home with him alive, providing them with nest-building materials, and with sugar for nutriment. He has one very interesting nest in a glass bottle, with its interior chamber well displayed. The roof of this is covered with depending globules of honey, so large as almost to conceal the minute clinging insect of which they really form a part.

But the marvelous feature of the case yet remains to be described. Not only is the abdomen of the ant converted into a receptacle for honey, but the whole internal economy of the body is transformed for this purpose. All the organs of the abdomen have quite disappeared: viscera, nerves, veins, arteries, have alike vanished; and there remains only a thin, transparent skin, which is capable of great distention. It is thus in reality a honey-cell, and much stranger than that of the bee, the waxen walls of the latter being replaced in this case by the tissues of a living animal. The creature can afford to dispense with the abdominal organs, since its life-duties are so metamorphosed that it has henceforth to act only as an animated sweetmeat.

Dr. McCook's observations enabled him to discover that the working ants, returning from their out-door foraging, with their bodies distended with the honey they have somewhere harvested, enter the chambers of the nest and eject this sweet fluid from their own mouths into the mouths of the honey-bearers, whose bodies become greatly distended with the delicious food. In other cases he perceived hungry ants seeking for a meal from the food thus generously stored up. The honey-bearer seemed to slightly contract the muscles of the abdominal skin, forcing from its mouth minute globules of honey: these clung to the hairs of the under lip, and were eagerly lapped up by the hungry ants waiting to be fed. It is probable, however, that these supplies are principally intended as winter stores for the workers, for the feeding of the larvæ, and for the dinner-table of the queen, who is, as usual, too proud or too dignified to do her own foraging.

The working ants take great care of their helpless honey-bearers. When one, through some convulsion of nature—occasioned perhaps by the tap of a gigantic human finger—looses its hold and drops to the floor of its chamber, it is at once picked up by a worker, and carried back to its old foothold on the roof of the apartment. How this minute creature can drag up a perpendicular wall a mass twenty times its own size and weight is only less surprising than it would be to see an adroit climber of the human race ascending the face of a precipice and pulling after him a ton weight.

With regard to the source of the honey, these ants are not known to feast on flowers, like bees and some of our home ants, nor could any evidence be found of the presence of the *Aphis*, or ant-cow, which many of our ants milk for its honey.

The honey-gatherer is difficult to observe. It is a nocturnal ant, keeping out of sight of the sun during the day, and only venturing forth at nightfall in search of food. Dr. McCook observed them, in the summer twilight, marching outward from the nest in long columns, and pursuing night after night the same paths. He watched them for a considerable time before he succeeded in finding the goal of these nightly expeditions. At length, discovering some ants on the twigs of a species of scrub-oak, which grew abundantly at the foot of the ridge, he observed that they showed a marked preference for certain small oak-galls which were ranged along the sides of the twigs.

The next thing to be done was to examine these galls. We are accustomed to associate galls with the idea of bitterness only, yet they proved to be the true honey-yielders. On the round, green masses minute drops of a sweet juice were found: this the ants eagerly licked up, passing from gall to gall until fully laden, or returning to the original gall at a later hour when fresh sweetness had exuded from it.

The gall-nut, it is well known, is an excrescence upon the leaves of a species of oak; it is produced by the puncture of a small hymenopterous insect for the purpose of depositing its eggs. A minute grub lies in the center of the soft mass which composes the gall. Whether the sweet juice came from this grub, or from the sap of the tree, was not readily to be discovered, though it was most likely an exudation of the sap.

All night the busy gatherers of sweets were occupied in collecting honey from the galls. Toward morning they were seen in great numbers returning to the nest, their bodies swollen with the night's harvest of honey, which, as we have said, is given to the living honeycombs within, being forced from the bodies of the workers and into the mouths of the honey-bearers, until, by the time the season is over, they present a remarkable distention.

This is about all that is known at present concerning the habits of these strange ants. They very likely have other sources of honey at other seasons; but the most interesting fact is the surprising mode of storage of this sweet food.

In New Mexico the inhabitants put these ants to a very peculiar use, supplementing their dinners with a plateful of honey-ants for dessert. The overladen insects wait in enforced patience while the preceding courses of the dinner are being eaten. The mode of partaking of this strange dessert is to pick up an ant, nip the honey-bag with the teeth, forcing its sweet contents into the mouth, while the remainder is thrown away. We are told that this is not so disagreeable a habit as it might at first sight seem, the skin surrounding the honey being reduced to a thin, transparent membrane, with nothing necessarily unpleasant in its character. Nevertheless, most of us will prefer to continue indebted to the bee for our supply of honey, leaving the ants to enjoy the fruits of their own labors.—*Journal of Science.*

SIZE OF BRAIN AND SIZE OF BODY.

By H. W. B.

IT may be stated generally that the larger the animal the smaller is the proportionate size of the brain. As an example of this we may take the case of two of the largest animals now living, viz., the whale and the African elephant. The whale possesses one of the largest brains that is found in any animal, but, if we compare the size of its brain to that of any of our domestic animals, such as the dog, we find that it has a very small brain in proportion to the size of its body. The same is the case with the brain of the elephant, which is certainly the largest brain of any land animal, but which, compared to the size of the body, is very small. Another set of animals in which the brain is comparatively small is the reptiles. This group includes a number of animals which are not included in the popular sense of the word, such as the crocodiles, the turtles and lizards, as well as the snakes. In these the brain is small comparatively to the size of the body, as it is also in the amphibia. The small size of the brain in these two classes of vertebrates is peculiar, as it runs through all the various groups, although most marked in the larger members of each one. The birds also follow the rule that the largest of them have smaller brains compared to their bodies than the smaller ones have. A good example of this may be seen in the case of the ostrich, which has the largest body of any member of the group, but a much smaller brain in proportion to its body than many of the smaller birds. As a class, however, the birds have large brains in proportion to their body, when compared to the other vertebrates, and so present a contrast to the reptiles, in which, as already stated, the brain is small throughout the whole group. In the next class of vertebrates—the Monotrêmata—the brain is large in proportion to their body, but it must be taken into account that this group contains very few large animals, being composed almost entirely of small ones. The size of the brain in the echidna, and the ornithorhynchus, both belonging to this group, is especially large in proportion to the small bodies which the animals possess. This is more remarkable when we consider the low position they occupy in the vertebrate series. In this manner we might go on through the whole series of vertebrates, showing how the larger animals have relatively smaller brains, and also the reverse, that the smaller animals have larger brains for their size.

We must now consider, however, the relative size of the brain in animals about the same size, as it is only in that way that we can gain information on the subject. Owing to the difficulties which attend the investigation of this subject, comparatively little is accurately known about it. It may be stated generally that the brain of domestic animals is larger than that of wild animals of a corresponding size of body. As an example of this we may take the case of the dog and the wolf. If the brains of those animals are compared, it will be found (if the animals compared are of the same size) that the brain of the dog is the larger. Again, if we compare the brains of a dog, a badger, and a musk-deer about the same size, we find that the brain of the dog is the largest, those of the other two animals being about the same size. It will be observed that, in classifying the size of an animal, we do not go by the height the animal stands, because many animals whose bodies are about the same size differ in height only on account of their legs being longer. In making comparisons, therefore, we compare animals whose bulk is the same, irrespective of the actual height they may stand from the ground. Among the wild animals of a similar size, we also find considerable difference between the comparative size of the brain and that of the body. As an example of this, we may take the case of the lion and tiger. The brain of the lion is much larger than that of the tiger ; however, that might be expected from the lion being a larger animal than the tiger ; but the brain is much larger in proportion than the difference of size of the two animals would account for : therefore the brain of the lion is larger, in proportion to the size of his body, than that of the tiger is in proportion to his body.

But we must now compare the size of the brains of domestic animals of the same size. Although the horse stands higher than the ox, yet both those animals may be classed together for the comparisons of their brain. We find that the brain of the horse is very much larger than that of the ox. The camel also may be included in this class, as being about the same size. Although many camels are larger, still the bulk of the body is not very much greater than that of the horse and ox. Its brain is very similar in size to that of the ox, but smaller than the horse's brain. The brain of the sheep is a good deal larger than that of the goat, although their bodies are similar in size. The sheep and the pig are also animals which we might classify if we do not take extreme sizes, but compare animals similar in age or bulk. We find that the pig's brain is larger than the sheep's, and corresponds in size very nearly to that of the dog. In the cat the size of the brain, in proportion to the body, is much larger than that of the domestic rabbit, although the size of the two animals is very much the same.

In these examples given we have not taken into consideration the order to which the animal belongs in the vertebrate series, but only compared similar sized animals, and in all cases we have compared the brains of adult animals. This is a very important point, as it is found that in all animals, including man himself, the size of the brain, in proportion to the size of the body, is much greater in young animals than it is in the adult. In some animals the head is found to grow enormously in size as the animal reaches adult age, but the brain does not increase to the same extent. There is generally some reason to be found for this in those animals where it takes place. For example, in the elephant the head of the young animal is by no means out of proportion to the size of its brain; but if we bisect the head of an adult animal we find that the brain only occupies a small cavity, and the rest of the skull is composed of plates of bone with air-cells between them. In the young elephant we find none of those plates and air-cells between the outer and inner layers of cranium, but simply the two layers of bone close to one another; but we will also find that at this stage the young elephant has no large tusks to carry, and its trunk is light, so that its head is comparatively light. The case is, however, quite different in the adult, when there are two large tusks and a large trunk to carry. In order to support this great weight he requires strong muscles. The great increase in the size of his head, therefore, is to afford a requisite extent of surface for the attachment of the muscles. In order to get this, combined with lightness, the skull is composed of those plates and air-spaces mentioned.

A very interesting question, but one which it is very difficult to answer, is whether the intelligence of the animal corresponds to the size of its brain. It is very difficult to make comparisons in many animals, as one animal shows his intelligence in one way, and another in another way. However, going over some of the animals whose brains we have compared, we may take as an example the horse and the ox. The horse has the larger brain, and he has undoubtedly the greater amount of intelligence. We find that horses can be trained to a great extent, as may be seen daily in a circus, but the ox has never been so trained. Again, a dog is the most intelligent animal there is, and he has a large brain in comparison to the size of his body. On the other hand, however, if we examine some of the Monotremata, we find, as already stated, that the brain is very large in proportion to the size of the body; but the animals of this group would by no means be taken as a standard of animal intelligence. It appears very probable, therefore, that in young animals and in the lower classes of the vertebrates the size of the brain has comparatively little to do with the intelligence the animal possesses, but that in the higher vertebrates there is some relation between the amount of intelligence and the quantity of brain-matter. The question may be asked, Why is it that the elephant, since it has the largest brain of any land animal, is not the most intelligent animal there is—more intelligent even than man, if the intelligence of an animal depends on the amount of its brain-matter? The answer to this question is easy. This animal being so large requires proportionally larger nerves and larger nerve-centers, to supply the muscles and sensory organs of his body, in the same manner that a larger magneto-electric machine is required when twenty electric lights have to be supplied by it than when it has to supply only ten. The elephant has, in reality, a smaller quantity of brain material available for his intelligence than the dog, because the dog has a much smaller body, and requires smaller nerves. Moreover, the intelligence, it has been proved, is situated in the upper part of the brain, or cerebrum, as it is called. Now, the dog's cerebrum is very much larger, in proportion to the size of his body, than that of the elephant, after allowing for the general law that larger animals have smaller brains in proportion to their body than smaller ones have. The number of smooth and tortuous eminences called convolutions, separated by grooves, which cover the whole surface of the upper brain or cerebrum has also been proved to have something to do with the amount of intellect of the animal. The brains of those animals which possess superior intellect are generally more highly convoluted and more deeply divided by the grooves than those of lower intellect. This may be very well seen by comparing the brains of the horse and the ox. It will at once be seen on looking at the brains of those two animals that the horse's brain is the more convoluted and altogether the more complex structure of the two. The same thing may be seen in the brain of the pig on comparing it with that of the sheep. As an example of brains where the convolutions are few in number and the grooves between them very shallow, we may take those of the echidna and ornithorhynchus, already mentioned as being very large in proportion to their bodies, while they themselves are of a low type. The intellect of those animals evidently does not correspond to the size of their brain. The probability is, therefore, that their brain-matter is of a low type and consequently a larger quantity of it is required. Besides these examples cited there are many more that could be brought forward. It may be stated generally, then, that the intelligence of an animal depends principally upon the size of the brain in proportion to the size of its body, the size of the cerebrum, and also upon the number of convolutions and the complexity of its structure, although there are many exceptions to this rule which we are still unable to account for.

Another interesting point in connection with this subject is the great increase in the size of the brain that has taken place within the last few hundreds of years, without a corresponding increase in the size of the body in all animals. This very interesting fact we learn from fossil zoölogy. The brain of animals at the present day is much more developed than it was in former times. This may be owing to the struggle for existence which there is, the animals which are weaker in body and intellect gradually being extinguished by the stronger, so that only the latter remain and are allowed to propagate the species. We know that exercise and training strengthen the brain and increase its weight in man, so the probability is the same thing takes place among the lower animals. There is every likelihood, therefore, that the brain will still go on developing as time advances.—*Land and Water.*

THE TEXTILE PLANTS OF THE WORLD.

DR. HERMANN GROTHE, of Berlin, has published a work on the textile fibers furnished by the world of plants, embodying the fruits of studies pursued among the yarn and cloth materials of all nations at the great Industrial Exhibitions that have been held at the European capitals and in Philadelphia. The subject is one of much interest, in an economical sense, and in the relation it bears to the development of early civilization. Men's first steps in civilization may be traced almost directly in their efforts to clothe themselves; and their first essays in skilled labor are made in the adaptation of the materials which nature has furnished them to use for dress. On the banks of the White Nile are tribes who content themselves with simple aprons of leaves, or less; and Sir Samuel Baker noticed that a great advance in general civilization had taken place when, after having spent several months among peoples of that grade, he came into Unyoro, where the people wore garments fashioned out of the bark of a fig-tree, which they had to prepare by soaking and beating with a mallet. Thrift seemed to follow naturally upon the acquisition of the taste for clothing, for the fig-trees have to be cultivated to secure a sufficient supply. Accordingly we are told, when a man takes a wife, he plants a certain number of the trees in his garden, as a provision for the wants of the family he has in prospect. A grade above the naked races are the Papuans of New Guinea, with their loin-girdles of grass or palm-leaves; and above these are the Maoris of New Zealand, with their cloaks of the leaves of an agave-like plant laid upon each other like scales. The South-Sea Islanders have in the paper-mulberry a plant which serves the same purpose to them as the fig-tree to the people of Unyoro, from the bark of which they prepare the *tapa* by soaking and beating. They illustrate another development of industry in the adornment of their clothes, for which they have invented an endless number of designs, many of them of considerable merit. This stage of civilization is also often marked by a corresponding development of the potter's art, and of skill in ornamenting vessels. From the method of using the whole stuff of the bark to the art of separating its fibers and spinning and weaving them into a cloth is a great step. The processes of spinning and weaving are as varied as are the people who carry them on, and are largely determined by the nature of the material to which they have to be applied.

Dr. David August Rosenthal, in his "Synopsis Plantarum Diaphorecarum" (1862, Erlangen), counts, among twelve hundred useful plants, three hundred and sixty species which are fit for weaving, spinning, basket-work, cordage, etc.—species which are distributed over the whole earth, and of which nearly every country has some which may be cultivated with profit.

Dr. Grothe divides the textile fibers into seed, bark, stalk, and leaf fibers. Those of the first class, the seed-fibers, are derived principally from the species of cotton, concerning all of which we have as yet no comprehensive treatise. Several other families of very diversified character afford seed-fibers, for which no method of application has yet been found which would permit them to be compared with the cotton. The plants affording valuable bark, or bark-fibers, are far more numerous. Dr. Grothe enumerates thirty-one families, of which seventeen are dicotyledonous, twelve monocotyledonous, one is a gymnosperm, and one is a fern. Among the dicotyledonous plants are species of flax, linden, birch, mallows, sterculiaceæ (or silk-cottons), thymelaceæ (Daphne, leatherwood), asclepiads, apocynaceæ (dogbanes), nettle-plants, leguminous plants, mimosæ, spurge, willow, myrtle, bread-fruit, compositæ, and byttneriaceæ. The cultivation of the flax-plant has extended to the antipodes. Near to it in importance are the plants of the linden family, which afford numerous species suitable for basket-work and for woven fabrics. At their head stands the corchorus (not the so-called *Corchorus japonicus*, or Japan rose of the gardens, which is a spiræa), of which the species olitorius and capsularis are the plants of the jute-fiber, and have recently attained an extraordinary value. The cultivation of these plants, which was formerly carried on only in India and the Sunda Islands, has spread to the Southern United States, Brazil, Australia, New Caledonia, Mauritius, Guiana, and Algeria, and the production of the fiber, according to Dr. Grothe, already equals half that of cotton. Other lindens worthy of notice for their textile value are the aubletia petoumo, of Guiana, and several species of triumphetta. The mallow family, to which the cotton-plant belongs, affords a great many textile plants of the genera abutilon, hibiscus, sida, lavatera, malva, althea, abelmoschus, etc.

Passing by the hemp, the value of which is generally recognized, we come to the nettle family, to some of the members of which an increasing degree of attention has been directed at all the great exhibitions since 1851. The common stinging-nettle has been used in Europe for a long time in making the nettle-cloth; the fibers of other species have recently been made into a handsome hair for dolls' heads, and might be put to more practical uses. Some twenty-four species of Urtica, Böhmeria, Puya, and Wood-nettle are enumerated as more or less valuable, besides the *Nerandia melastomæfolia*, which is used in the Sandwich Islands. Of the whole number, *Urtica nivea* stands in the highest estimation as the plant from which the well-known China-grass or grass-cloth is made. It is cultivated extensively in the provinces of China south of the Yang-tse-kiang, the export from which had reached about thirty-five hundred tons in 1872, and is now estimated at about eleven thousand tons. The fiber is used in Japan for the finest threads and cloths, and an active manufacture has been carried on since 1660, hemp and jute having been used before that time. The Puya and the Neilgherry nettle (*Urtica heterophylla*) are also highly valued for their fibers. Another family, allied to the nettle, the Antidesmeæ, is represented in the Malabar flax (*Antidesma alexiterium*), which is employed for spinning and in ropes. Among the monocotyledonous families that afford useful fibers are the lilies, irises, amaryllises, bromeliaceæ (or pineapple family), palms, pandanus (or screw-pine), rushes, grasses, reeds, and sedges. Of the plants of these orders most famous for their fibers are several species of agave and fourcroya, which afford the strong pito hemp, several species of anana (bromeliaceæ), and the bananas, one of which, the *Musa textilis* of the Philippine Islands, produces the Manila hemp, one of the handsomest and most valuable of all the fibers.

SKETCH OF DR. CHARLES F. CHANDLER.

PROMINENT among the men who have won large distinction by varied and valuable labors in the field of science in this country, stands the name of the subject of the present notice. His career has been one of such eminent public usefulness in several departments of activity, which he has efficiently promoted both by his scientific attainments and his marked executive ability, that no biographical sketch of him can be given that does not involve some account of the various projects, measures, and reforms, with which he has become identified. Science is devoted to the interests of truth, but that truth is for the service of humanity; and the work of research becomes of the highest value only in its large Baconian application to the "relief of the estate of man." It is through the intelligent and well-directed efforts of such men as Dr. Chandler that the fruits of science are applicable for the large amelioration and advantage of society. It is, moreover by the substantial and lasting benefits thus gained that the community is led to recognize its great debt to science which it discharges by increasingly liberal provisions for its cultivation and development.

Professor Chandler was born at Lancaster, Massachusetts, in 1836. His father became a merchant in New Bedford, where he still resides. On the maternal side he is descended from the rebels of the Revolution and on his father's side from the Tories. His maternal grandfather was John Whitney, an old Boston merchant; his grandmother was a daughter of John Slack, who fought at Lexington. The Chandlers originated with William Chandler and Annis his wife, who arrived in Roxbury, Massachusetts, from England in 1637. It was at Lancaster, Massachusetts, in the house of his grandfather, Nathaniel Chandler, who graduated at Harvard in 1792, that Professor Chandler was born.

Hunting chiastolites and other minerals at Lancaster during vacations, and attending lyceum lectures and listening to the elder Agassiz, led him to take an early interest in scientific studies, and while still a boy he turned his workshop in the attic into a laboratory. After graduating at the high school, he continued his classical studies privately with a friend of the family for a year, and then pursued his professional studies at the Lawrence Scientific School, and the Universities of Göttingen and Berlin.

His teachers in chemistry have been Horsford, Wöhler, and Heinrich Rose. Through the influence of Wöhler and his friend Professor Joy he obtained the position of private assistant to Rose during the year he spent in Berlin, in whose laboratory his only companion, besides Rose and his lecture assistant Oesten, was the now famous Nils Erich Nordenskjöld, the Arctic explorer. In physics he studied with Weber, Dove, and Magnus; in mineralogy he attended the lectures of Professor Cooke at Harvard, Von Waltershausen in Göttingen, and Gustav Rose in Berlin. In geology he listened to the lectures of Agassiz. In 1856 he received his degree of Doctor of Philosophy and Master of Arts at Göttingen, publishing a dissertation containing the results of miscellaneous chemical investigations.

Soon after his return to America he accepted the position of assistant at Union College under his friend Professor Joy; and when, soon after, this gentleman was called to Columbia College, Chandler immediately succeeded to his duties, and began lecturing to the Senior Class, though not yet "of age"—politically. He remained here for eight years in charge of the laboratory, and lecturing to the college classes on general and agricultural chemistry, mineralogy, and geology.

In 1864 Professor Chandler became connected with Columbia College, joining Professor Egleston and General Vinton in the experiment of starting a School of Mines. The project originated with Professor Egleston, who, with his friend Vinton, had recently graduated at the École des Mines in Paris. It was not considered very promising, but the three professors were willing to begin without salaries. Mr. George T. Strong, W. E. Dodge, Jr., and several others, furnished about three thousand dollars to equip the modest laboratories. Hon. Gouverneur Kemble presented a fine cabinet of minerals. Dr. Barnard, the newly-elected President of Columbia College, Dr. Torrey, and the other Trustees, encouraged the enterprise in every possible way, and some vacant rooms in the basement of the college were assigned for laboratories. The success of the school was marvelous. Provision was made for twelve students; twenty-four came the first day. During the entire winter the carpenters and gas-fitters were constantly at work erecting new tables for additional applicants, and the number of pupils reached forty-eight. The Trustees of the College responded liberally. During the first vacation they placed a large four-story building at the disposition of the school, with ample funds for the equipment of laboratories and cabinets. Accommodations were arranged for seventy-two pupils. During the second year the school was thronged; eighty-nine students were in attendance. The success of the new school seemed so well assured that the Trustees arranged to place it on a substantial basis as a coördinate department of the college. Professor J. S. Newberry was called to the chair of Geology, relieving Professor Chandler of this subject, and a full faculty of professors and assistants was established. A new building was erected, and equipped with laboratory accommodations for one hundred and fifty pupils; these were outgrown, and a few years ago still larger ones were erected. The school is now in its sixteenth year; it has about two hundred and fifty students, pursuing a four years' course of study. Professor Chandler has been Dean of the Faculty of the School from the beginning, and has been the executive officer, besides having charge of the laboratories and giving his regular courses of lectures. The Assay Department was the especial hobby of Professor Chandler, and, with the aid of his successive assistants, Miller, Day, Blossom, and Ricketts, has been made the most complete of its kind to be found anywhere. To facilitate the work of assaying gold and silver ores, he devised an improved system of weights, which has been generally adopted by assayers.

When Professor Chandler first came to New York, he was asked to lend a hand in the development of the College of Pharmacy. This institution was then occupying a single room in the old University building on Washington Square, and numbered about thirty students.

Three evenings a week, all winter, Chandler lectured there year after year. The active exertions of the faculty and the trustees, and the interest manifested by the New York druggists, have built up from this small beginning a most flourishing school of three hundred pupils, which is able now to own a fine building, with laboratory and lecture-halls.

At the death of Professor St. John, Professor Chandler succeeded to his chair of Chemistry and Medical Jurisprudence in the College of Physicians and Surgeons, which he now holds. Here his voice has always been raised in favor of a much more exacting system of medical education, and has not been without effect, in the recent radical improvements which have been adopted in this institution, involving an extension of the session to seven months, written examinations, etc.

In 1866 Professor Chandler was invited by the Metropolitan Board of Health to do some gratuitous chemical work. He accepted the invitation, and so impressed the Commission with the importance of his work that, at the end of the year, they created the office of Chemist for him, which he held till 1873, when he was appointed by Mayor Havemeyer President of the Board. In 1877 he was reappointed, for six years, by Mayor Ely. As Chemist to the Board of Health, food and water supply were made the subjects of careful investigation. The absurdity of the annual complaints with regard to the quality of the Croton was clearly established, as was also the danger of drinking water from any of the city wells. It was also shown that the popular belief in the wholesale adulteration of the common articles of food, such as flour, bread, sugar, etc., was unfounded. The shameful condition of the milk-supply was pointed out, and it was shown that for every three quarts of milk there was added at least one quart of water, to say nothing of the frequent removal of a considerable portion of the cream. The fact that most of the condensed-milk companies skimmed the milk before they concentrated it and sold the cream separately was also published. A fraud on the citizens, amounting to at least ten thousand dollars a day, was traced to the milk-dealers.

After Dr. Chandler was made President of the Board of Health, he made the milk question his special study, and carried on a successful warfare against the dishonest dealers. He rightly assumed that, as milk was the chief diet of the one hundred and thirty thousand children in New York, under five years of age, it was the most important article of food for municipal supervision. His reforms were not accomplished without very sharp fighting. The milk-dealers organized, and secured the services of lawyers and chemists, who attacked both the laws and the chemical methods. After prolonged litigation, the Court of Appeals affirmed the ordinances of the sanitary code, and the lactometer as used by Dr. Chandler and his inspectors received the scientific endorsement of the best chemists in the country, including

Barker, Morton, Silliman, Caldwell, Goessmann, and many others, as well as the more practical endorsement of verdicts from the Judges of the Courts of Special Sessions and the jury of the General Sessions. At least fifteen thousand dollars has already been paid by milkmen in fines for watering and skimming milk. This investigation of the lactometer is important and interesting, for, while the Swiss and German investigators use it with the greatest confidence, the English analysts were shaken in their faith by the special pleading with which Wanklyn recommended his own method of analysis.

At the same time an investigation of the liquors sold in the commoner resorts was undertaken. The Metropolitan Excise Commissioners decided to withdraw the license of every one of the eight thousand dealers who should be found selling adulterated liquors. Professor Chandler was engaged to make the analyses on terms which might well have turned the head of any chemist. He was to receive twenty dollars for each analysis ; there were eight thousand dealers, and there were likely to be three or four samples from each. But when he came to examine the first installment of forty samples of whisky, gin, rum, and brandy from Mulberry, Mott, Baxter, and other streets of that character, he was compelled to report that while the brandy was all factitious, and the basis of the others was common whisky, there was no adulteration in the sense of anything added of an injurious character. Some of them had been carelessly made and contained more fusel-oil than others, but the poisonous constituent was the alcohol. This ended the projected reform of the liquor-traffic by chemical analysis.

An effort was made to put a stop to the sale of poisonous cosmetics, especially the various preparations of lead salts which are employed either on the skin as a white enamel or upon the hair to restore the original color. His analyses were widely published.

The most important work of Professor Chandler was, however, the investigation of kerosene accidents, which were of very frequent occurrence, not only in New York, but wherever this cheap illuminator was used. It was supposed by the world at large that the accidents were an unavoidable incident to the use of the oil. Kerosene came in as a substitute for "camphene" or "burning-fluid," which was inherently dangerous and could not be made safe. Kerosene was supposed to be similar in chemical composition and properties, and the accidents were generally attributed to carelessness. In 1869 Chandler began his work on this subject, his first report to the Board of Health bearing date January 11th of that year. It was a simple statement of the chemical nature of petroleum and its products, explained the process for refining the oil, and clearly established the fact that the dangerous character of the oils in use was due to the fact that the refiners, in order to realize a profit of two or three cents per gallon, left a certain quantity of the highly inflammable naphtha in it. He also reported the fact that he had purchased seventy-eight samples of oil from as many different dealers in the city, and not a single one of them was safe. Some were pure naphtha.

So convincing was the statement that it was taken up all over the country. The report was reprinted everywhere, and the statements were made the basis of legislative action in most of the States. The report was followed by a second in July of the same year, a third in 1870, and a very elaborate report of 110 pages in 1871. Ten thousand copies of the latter were printed and circulated by public-spirited citizens in New York. It was largely reprinted in Switzerland, extensively quoted in France and Germany, and freely used and quoted by the Select Committee of the House of Lords in their report on the Petroleum Bill, 1872. In fact, Professor Chandler was invited to go to England to testify before this committee. He did not content himself with writing on the subject, but lectured in the hall of Cooper Union, the Academy of Music, and in Washington. Not only were the dangers of poorly refined oil exposed, but also the entire failure of all the safety-oils, safety-lamps, safety-cans, vapor-stoves, etc., and patented processes for making naphtha and benzine safe. It was shown that, with proper oil, accidents would never occur, while there is no method by which bad oil can be used with safety.

In New York City alone there were, in 1870, a hundred and fifty-seven fires known to have been caused by kerosene and naphtha, eighteen per cent. of the whole. There were also twenty-one deaths from the same cause, with thirty-nine deaths from clothes taking fire in ways not stated. It was estimated that from one to two thousand persons were killed annually by these accidents, before the labors of Chandler called attention to the cause and indicated the remedy.

One of his most comprehensive investigations resulted from the action of the Board in suppressing the gas nuisance. All the gas companies purified their gas by what was called the dry-lime process. The foul lime when removed, as it was daily, from the purifiers, disseminated a stench throughout the entire city. This odor was by most citizens attributed to the sewers. When it was fully realized that it came from the gas-works, the companies were appealed to, and, with one exception, they introduced improvements by which the odor was suppressed. One company, however, maintained that no odor emanated from their works; that the odor was not disagreeable; that it was wholesome, as children suffering from whooping-cough were brought to breathe it; that they could not avoid making it; and, finally, if they did, the gas would be too bad to burn in dwellings. The result of these claims was a most elaborate trial before a referee. The gas company produced experts and other witnesses to sustain the above views, and Professor Chandler combated them with the best foreign authorities on gas-making. The evidence was subsequently published in the Report of the Board for 1869, and is one of the most complete discussions of gas-purification which has ever appeared. The Board decided against the company, and the gas nuisance ceased.

As President of the Health Department of New York, Professor Chandler has held a most responsible position for the past six years. During this time he has had associated with him in his work Dr. S. O. Vanderpoel, the Health Officer of the Port, and Dr. Stephen Smith for the first two, and Dr. Edward G. Janeway for the past four years. These men have always worked in complete harmony.

The present Board of Health was organized under the charter of 1873, which was a modification of that of 1870, which abolished the Metropolitan Board. This latter was established in 1866, and a very perfect system of sanitary legislation and supervision was inaugurated by the health laws of that year. The Sanitary Code of New York was the first result of that legislation. New enactments have been made from time to time, and it is believed that New York City now possesses a more extensive and perfect system of sanitary supervision than any other city in America or Europe ; and its laws and code, as well as its work in general, have been made the model for similar work throughout the country. When the present Board organized, it adopted a thorough civil-service system, and there has not occurred a single instance since that time in which it has been departed from. Dr. Chandler's first labors in 1873 were directed to the purification of the atmosphere of New York, and his first summer was spent in the most active warfare on all kinds of stench-producing trades.

The war was not confined to the land, as a naval engagement occurred on more than one occasion. At last there were no odors left save those which were wafted across the East River from Newtown Creek and Hunter's Point, and which the Board of Health was diligently combating when the farce of the indictment of its members was enacted by the grand jury.

Judge Sutherland promptly quashed the indictment on the ground that neither a moral nor a legal excuse existed for it. That the Health Board was not inactive is shown by the fact that suits were brought against the city for nearly five hundred thousand dollars for their acts in suppressing nuisances in 1873 and 1874 ; and that the members acted with judgment is shown by the fact that in every one of these suits they were victorious.

One of the most creditable acts was the removal of the two-story sttuctures, which had been erected over the half of the roadway of the public streets adjacent to Washington Market, and almost entirely surrounding the block which the market occupies. Every effort had been previously made by other boards to remove them, but in vain. After exhausting every other method, the Board of Health in 1873 decided to use force, and one quiet summer evening Dr. Chandler led an army of one hundred and fifty carpenters and laborers, three hundred policemen, and a corps of surgeons to the market, and before morning the entire line of buildings was leveled, and one of the most outrageous abuses that had grown up under political protection was abolished.

Among the numerous sanitary reforms secured by the present Board of Health, may be mentioned the system of gratuitous house-to-house vaccination established in 1874, which has already resulted in vaccinating over 360,000 persons, and the complete suppression of small-pox; the reform in the construction of tenement-houses; the employment of a special corps of fifty physicians during the five hot and damp weeks which occur in the latter part of July and the early part of August, and which were formerly so fatal to infants, killing sometimes eight hundred or one thousand in a week. The physicians make a house-to-house visitation, prescribe for the sick children, supply medicines, and distribute printed directions among the mothers. The Health Department in its varied work of recording the marriages, births, and deaths, preventing and caring for contagious diseases, disinfecting, sanitary inspection, and the abatement of nuisances, meat and milk inspection, employs a corps of one hundred and thirty men, besides the special summer corps of fifty physicians and the fruit-inspectors and extra disinfectors—requiring an annual appropriation of $250,000. The return for this large expenditure is seen in the remarkable improvement in the public health. In 1866, fifty-three per cent. of the total deaths were of children under five years of age. This percentage has steadily diminished, till it is now less than forty-six, which proves an actual saving of four thousand children's lives in a single year, to say nothing of all the sickness prevented in our population of over 1,100,000.

The sanitary chemistry of water has been a special subject of investigation with Dr. Chandler, and he has been relied upon to decide important questions with regard to the selection of water for supplying Albany, Yonkers, and several other cities. He has also been engaged in several important investigations on the pollution of water by factories, and the prevention of boiler incrustations.

During the past summer Dr. Chandler was made chairman of a committee to draw up a scheme for disinfection, to be adopted by the National Board of Health. The other members of the committee were Drs. Vanderpoel, Janeway, Henry Draper, Barker, and Remsen.

Professor Chandler's most elaborate chemical work has been the investigation of American mineral waters. With the aid of his assistants he has analyzed sixteen of the springs and artesian wells at Saratoga, besides many more sulphur and other springs at Chittenango, Florida, N. Y., and elsewhere.

Dr. Chandler, in connection with his brother, Professor W. H. Chandler, of the Lehigh University, started a monthly journal of chemistry, called "The American Chemist." It contained the results of many researches, and was a valuable periodical for those engaged in chemical pursuits, but was not a success financially, and, after running six years with very considerable loss, it was discontinued. Professor Chandler has devoted much attention to chemical industries, and has written and lectured upon them frequently. He is often consulted by both manufacturers and the courts in regard to scientific questions involved in the arts.

Dr. Chandler is an effective popular lecturer, having an excellent voice, and a clear, direct, and vigorous style of delivery. His subjects chosen are those of technical and special interest, such as petroleum and kerosene accidents, water-supply, gas-lighting, prevention of fires, public health, etc., which are always practically and instructively treated. These lectures are of very great value, and, having been given in most of our principal cities, have exerted a wide and excellent influence. He has also been remarkably active as a writer. The list of his scientific papers is very comprehensive. It embraces the results of varied original investigations, covering wide ground, and making a catalogue too extensive for insertion here. He is the author of numerous scientific papers, cyclopædia articles, and addresses and reports, which have been published in the journals and proceedings of societies.

Dr. Chandler was President of the Convention that met at Northumberland in 1874 to celebrate the anniversary of the discovery of oxygen by Dr. Priestley. He published in full the interesting proceedings and addresses in "The American Chemist." The success of the Northumberland meeting led to the founding of the American Chemical Society, of which Chandler was one of the most active projectors, and of which he has been a Vice-President from the beginning, having refused the regular nomination for President almost every year since it was organized.

Besides the degrees of Doctor of Philosophy and Master of Arts, obtained as a student, Professor Chandler has received the honorary degree of Doctor of Medicine from the University of New York and Doctor of Laws from Union College. He is a life-member of the Berlin, Paris, and American Chemical Societies; he is also a member of the National Academy of Sciences, the London Chemical Society, the Sociedad Humboldt of Mexico, the American Association for the Advancement of Science, the American Philosophical Society, New York Academy of Sciences, and several pharmaceutical, sanitary, and other societies.

CORRESPONDENCE.

THE ORIGIN OF CRIMINAL LAW.

Messrs. Editors.

In the very able article under the above heading, by Mr. W. W. Billson, published in your February number, I notice the following: "The law of the Allemans, which, while undertaking to enforce compositions for stale offenses, conceded to injured parties the privilege of righting themselves on the spot, and in the first transport of passion, finds a counterpart in the . . . . distinction made in the Twelve Tables between manifest and non-manifest theft. Persons detected in the act of stealing, or with the booty in their possession, were liable to the punishment of death . . . . while, if detected under other circumstances, they were only obligated to refund double the value of the stolen property."

Then, after some comments, the author quotes from Sir Henry Maine: "It is curious to observe how completely the men of primitive times were persuaded that the impulses of the injured person were the proper measure of the vengeance he was entitled to exact, and how literally they imitated the probable rise and fall of his passions in fixing the scale of punishment" (pp. 442, 443).

It may not be inappropriate to point out that a survival of the same feeling that gave rise to the practices quoted above seems still to be in force. 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, *stolen* the goods, and *escaped* with them. Surely the "*impulses*" of the injured person are allowed to have an influence here; for he may inflict much more severe punishment, by his own hand, in the first heat of his anger, upon him who is only attempting a crime, than he may inflict through the courts, after his anger has cooled, upon the successful perpetrator of crime.

Charles J. Buell.

Rosendale, New York, *January* 19, 1880.

FROST PHENOMENA.

Messrs. Editors.

Reading the article in the March number of "The Popular Science Monthly," on the effects of frost in southern Russia in the winter of 1876–'77, reminds me of an unusual phenomenon at Vienna during the same winter. There were eleven days of perfectly uniform weather, the thermometer standing just above freezing in the daytime, with a fog, and a very faint southerly wind. At night it fell to just below, with bright starlight.

The result was that everything—houses, trees, lamp-posts, fences, statues—was covered with a stiff white hoar-frost on the windward side, and on this side only, the fine acicular crystals growing to a length of *five inches* on the trees, and of three or four on the iron and stone work.

The mass of crystals was always thicker at the end farthest from its support. A twig half the diameter of a pencil carried a fringe an inch thick at the edge. The crystals were horizontal, and so light that the twigs did not bend perceptibly beneath the weight. On the first warm day they were gone.

Very truly yours,

W. S. Bigelow.

Boston, *February* 22, 1880.

EDITOR'S TABLE.

SOME FEATURES OF THE INTEROCEANIC CANAL QUESTION.

The presence of M. Ferdinand de Lesseps in this country has precipitated the important question of a change in our national policy regarding an interoceanic canal across the American Isthmus. Let us briefly glance at the history of the subject, that we may understand the import of the new departure.

It is customary to rail at trade as a selfish and sordid occupation; but, as the laws of human development are better understood, it is found that the exchange and distribution of the products of human industry constitute one of the most powerful of all agencies of social amelioration and the improvement of the condition of mankind. The discovery of America, the greatest of all discoveries, may be said to have doubled the habitable world, and to have opened a new destiny for man upon earth; yet it was but an incident in the progress of commerce. The blind passion for wealth was the impulse that drove men to the exploration of the unknown globe; and, as often occurs in investigation, the search for one thing led to another of far more value and importance. To increase Oriental trade by finding a new and shorter route to the Indies was the object of Columbus; he discovered a new land, and died in the conviction that it was Asiatic, and that he had brought "the fabulous wealth of Ind" within the immediate grasp of Europe.

Yet, seven years after the death of Columbus, Balboa crossed the Isthmus of Darien and discovered the Pacific Ocean. So it was not India that had been reached, but a new world that had been found. The old problem, therefore, still remained, how to get to the Indies by a western route; but the question was now how to find a passage through. All navigators were alert in quest of a strait that should lead into the Indian Ocean, and the incentive that inspired the enterprise of Columbus animated his successors during half a century later. Prescott says that the discovery of a new and shorter route to the Indies "is the true key to the maritime movements of the fifteenth and the first half of the sixteenth centuries."

But, failing to find "the secret of the strait," men of enterprise began to think of cutting the knot by opening an artificial waterway for ships across the American Isthmus. The Spaniards led in this project of uniting the opposite harbors by a canal; and Galvao, in 1528, proposed to Charles V. to open a ship communication between the oceans at Panama. Plans and surveys were afterward made for this purpose. In 1534 Charles V. gave instructions to Cortez to seek such a route. In 1551 Gomara, author of the "History of the Indies," proposed three routes, including Nicaragua. In 1567 Antonelli was sent by Philip II. to explore with reference to a ship-canal. In 1795 William Patterson, founder of the Bank of England, and a man of comprehensive views, who had possessed himself of an extensive and minute knowledge respecting the institutions and commerce of foreign countries, obtained the royal sanction to a project for colonizing Darien, one of the objects of the enterprise being to cut a canal through the isthmus. The expedition was attempted, but proved a disastrous failure. During the next hundred years various projects were suggested, and explorations made by citizens of different countries with a view of overcoming this barrier to navigation; and in 1804 Humboldt gave a new interest and impulse to the subject by publishing a careful discussion of the relative merits of several routes for an interoceanic canal. As the commerce of the world increased in the early part of this century, the problem became still more urgent, and projects for solving it multiplied—Spain, France, Holland, England—all the leading maritime nations contributing schemes and projectors for the undertaking.

Thus, for three centuries and a half the question of piercing the American Isthmus has been universally recognized as a world's question, as the common interest of all nations, and as open to anybody who had the ability and the perseverance to accomplish it. For two hundred years before our nation came into existence this was the broad view taken of the enterprise in all countries; and, when the United States first became interested in the subject, it was also as a project concerning alike the whole civilized world.

So far as we learn, the first action

taken by the American Government in relation to this question was in response to an appeal from the Central American Republic. Señor Canaz, its Minister at Washington, in a note addressed to the Department of State in 1825, proposed the coöperation of that republic with the United States in opening a canal through the province of Nicaragua. Mr. Clay replied to it, and instructed Mr. Williams, then our Minister in Central America, to investigate the practicability of the Nicaragua route. Through Williams's influence a contract was made with the Central American Government for the construction of a canal through Nicaragua "for vessels of the largest burden possible." It was proposed to raise a capital of only $5,000,000 for the entire work; but even that amount could not be obtained.

The Central American Government then applied to Holland for coöperation, and a Dutch company was formed in 1830 to construct the canal; but owing to European political disturbances it could not carry out its agreement, and the Central American Republic renewed its application to the United States as the country that should naturally have the preference.

The project was again brought up under Jackson's Administration, and in 1831 Mr. Livingston, Secretary of State, instructed Mr. Jeffers, American *chargé* in Central America, as follows: "You will endeavor to procure for the citizens of the United States, or for the Government itself, if Congress should deem the measure constitutional and proper, the right of subscribing to the stock; and you will, in either case, present and transmit such plans, estimates, and other information relative to the projected work as may enable us to judge of its feasibility and importance."

Four years later, on the 3d of March, 1835, the Senate of the United States adopted the following broad and liberal resolution: "*Resolved*, That the President of the United States be respectfully requested to consider the expediency of opening negotiations with the governments of other nations, and particularly with the Governments of Central America and New Granada, for the purpose of effectually protecting, by suitable treaty stipulations with them, such individuals or companies as may undertake to open a communication between the Atlantic and Pacific Oceans by construction of a ship-canal across the isthmus which connects North and South America, and of securing for ever, by such stipulations, the free and equal right of navigating such canal to all such nations, on the payment of such reasonable tolls as may be established to compensate the capitalists who may engage in such undertaking to complete the work."

Again, four years later, in 1839, the American House of Representatives adopted a resolution reaffirming the ground taken by the Senate, and requesting the President to consider the expediency of negotiating with other nations "for the purpose of ascertaining the practicability of effecting a communication between the Atlantic and the Pacific Oceans by the construction of a ship-canal across the Isthmus, and of securing for ever, by suitable treaty stipulations, the free and equal right of navigating such canal to all nations."

The same policy was even more broadly and emphatically announced by the United States Government in 1850, in the Clayton-Bulwer Treaty. That convention contains the following declarations:

"The Governments of the United States and Great Britain hereby declare that neither the one nor the other will obtain nor maintain for itself any exclusive control over said ship-canal; agreeing that neither will ever erect or maintain any fortifications commanding the same or in the vicinity thereof, or occupy, or fortify, or colonize, or assume or exercise any dominion over

Nicaragua, Costa Rica, the Mosquito Coast, or any part of Central America; nor will make use of any protection which either affords or may afford, or any alliance which either has or may have to or with any state or people for the purpose of erecting or maintaining any such fortification." Moreover, that "vessels of the United States or Great Britain traversing the said canal shall, in case of war between the contracting parties, be exempted from blockade, detention, or capture by either of the belligerents; and that this promise shall extend to such a distance from the two ends of the said canal as may hereafter be found expedient to establish"; that "they will guarantee the neutrality thereof, so that the said canal may for ever be open and free"; and that they "will invite every state with which both or either have friendly intercourse to enter into stipulations with them similar to those they have entered into with each other."

This is solid American ground. These deliberate and explicit declarations of both Houses of Congress and of the treaty-making powers of Government must be taken as expressing the national conviction—1. That the construction of a canal at the American Isthmus is an open project to be entered upon by any "capitalists," "individuals," or "companies" that may undertake it; 2. That it is a great international work to be under the joint control of the nations; and, 3. That the international protectorate is to be secured by treaty arrangements which it is proper for the President of the United States to initiate.

This is the just and honorable historic position of the American Government, and, as we may fairly assume, of the American people, in relation to this great enterprise. It is a definite and explicit line of public policy which has been variously and repeatedly proclaimed without protest or dissent. We have recognized the great desirableness of the interoceanic canal for this country, and its importance to the world; and we have pledged the faith of the republic to coöperate with other nations in affording international security to whatever individual or company would carry out the work.

Ferdinand de Lesseps now comes forward and offers to construct the canal. He is no dreamer, but a man of action. He has had experience in this work, and means business. Fortified by the almost unanimous approval of a large convention, which represented the best engineering skill of the age, he has determined the plan and route of a canal that he thinks will best meet the demands of the future; and stakes his reputation upon its practicability. M. de Lesseps's character gives seriousness to the proposition, and probably brings the measure nearer a practical realization than it has ever been before. It is a question that can not much longer be postponed.

And now come grave intimations that the American Government is to reverse its historic policy on the Isthmian Canal question. The honorable and consistent ground it has hitherto maintained is to be abandoned, faith is to be broken, pledges repudiated, and treaties abrogated. The canal is not to be controlled by international law, and the coöperation of maritime nations, but it must be exclusively controlled by the United States. Whoever makes it, and whoever pays for it, we are to seize it and hold it whenever we please. A select committee of the House of Representatives on the Interoceanic Canal has unanimously recommended the immediate adoption of the following joint resolutions:

Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled:

That the establishment of any form of protectorate of any one of the Powers of Europe over the independent states of this continent, or the introduction from any quarter of a scheme or policy which would carry with it a right to any European Power to interfere with their concerns, or to control in any other manner their country, or to transfer to any such Power, by conquest, cession, or acquisition in any other way, of any of those states, or any portion thereof, is a measure to which this Government has, in the declaration of President Monroe, in his message of December 2, 1823, and known as the "Monroe doctrine," avowed its opposition; and which, should the attempt be made, it will regard and treat as dangerous to our peace, prosperity, and safety.

2. *Resolved*, That it is the interest and right of the United States to have the possession, direction, control, and government of any canal, railroad or other artificial communication to be constructed across the isthmus connecting the American Continents, for the transfer of vessels and cargoes from the Caribbean Sea to the Pacific Ocean, whether the same be built or constructed at Panama, Nicaragua, or elsewhere; and, in view of the magnitude of this interest, it is the duty of the United States to insist that, if built, and by whomsoever the same may be commenced, prosecuted, or completed, and whatever the nationality of its corporators or the source of their capital, the interest of the United States and their right to possess and control the same will be asserted and maintained, whenever in their opinion it becomes necessary.

3. *And be it further resolved*, That the President be requested to take the steps necessary and proper for the abrogation of any existing treaties whose terms are in conflict with this declaration of principles.

There is, of course, no mistaking the significance of the position here taken. Whoever constructs the canal, and wherever the money comes from, this nation is to take possession of it and to maintain it. The newspapers have prepared us for this by declaring that the canal must be ours even at the cost of war, and though it be necessary to raise armies and navies to fight the whole world. Even so grave a journal as "The Nation" declares, and reaffirms in a subsequent issue, "Wherever and whenever it [the canal] is constructed it will become the most sensitive and vital part of our interstate and international commercial system, and we must be prepared to protect it from the evil of local revolutions and foreign aggression, to seize it when necessary, and successfully defend it against the two greatest naval powers in the world. The completion of such a canal involves, therefore, the creation and maintenance of a naval force in the Atlantic and Pacific capable of contending with that of any possible European combination." And here comes the "New York Tribune," formerly the champion of peace, industry, and the ascendancy of civil rule, but now viewing the Interoceanic Canal as first of all a question of war. International law, the honor of governments, and mere paper protectorates are disparaged, and our policy is proclaimed to be "the erection of American forts, manned by American soldiers, at the two mouths of the canal."

The pretext for all this is the "Monroe doctrine," reaffirmed in the first of the above resolutions. Let us see what this doctrine is, and how it has been perverted to base ends for which it was never designed.

When the career of Napoleon ended, and the legitimate kings of Europe were again restored to their thrones, there came a reaction in favor of "strong governments," that is, government by despotic coercion in opposition to free constitutional governments. This resulted in a propagandism of tyrannic rule. A Holy Alliance was formed, embracing Russia, Austria, Spain, Prussia, and France, which, under pietistic pretenses, aimed at the repression of free institutions. The spirit of revolt against Old-World despotism had spread widely in Central and South America; and Venezuela, New Granada, Mexico, Colombia, Peru, Guatemala, and Brazil had declared themselves free and independent. It was in the programme of the Holy Alliance to regain control over the revolted American colonies, and reëstablish the European system.

In this enterprise England did not join, nor did she at all approve of it. Mr. George Canning, the English Prime Minister, called the attention of the United States to the Continental plots, and asked if this Government intended to allow the subjugation of the

American republics by foreign Powers. In his next message President Monroe said:

> We declare that we should consider any attempt [of the allied Powers] to extend their system to any part of this hemisphere as dangerous to our peace and safety. . . . With the governments who have declared their independence and maintained it, and whose independence we have on great consideration and on just principles acknowledged, we could not view any interposition for the purpose of oppressing them or controlling, in any manner, their destiny by any European Power, in any other light than as the manifestation of an unfriendly disposition toward the United States.

This was a courageous and timely and most proper declaration, and it had its effect: the Continental despotisms abandoned their projects of interference. A revived Napoleon, indeed, revived the experiment in the case of Maximilian of propagating the European system on this continent; but it quickly ended in disaster, carrying Napoleon himself with it and turning France into a republic.

The emergency which called forth the declaration of this doctrine having passed away, it has since been used as mere political stock buncombe to cover unscrupulous projects which could not be openly and honestly defended. At first an expression of national dignity and justice in defense of the rights of the weak, it has been made the excuse for subverting the very objects it was designed to promote. Conceived and promulgated in the interests of freedom, it has been villainously pressed into the interests of slavery. When there was apprehension that Spain might in some future contingency give liberty to the blacks of Cuba, and thus endanger the American slave system by the contagion of moral example, the Monroe doctrine was invoked to forestall the humane possibility. Buchanan, of Pennsylvania, and Mason, of Virginia, fulminated the "Ostend Manifesto" to prevent "foreign interference on this continent," that slavery might be perpetual; and this in the name of the Monroe policy.

And now it is proposed again to pervert the Monroe doctrine to an end never dreamed of by its promulgators, and in point-blank subversion of its legitimate objects. We have already shown that, promptly following the Monroe declaration, came Congressional instructions to the President to open negotiations with other nations for the encouragement of all canal-constructors. It was then well enough understood that the Monroe doctrine was declared, to stop the extension of political despotisms, not to stop the free and beneficent extension of commerce. It was to prevent aggressive interference with young and feeble republics on this continent, that they may take their equal and independent place among the nations. In the exercise of its national rights thus affirmed, the Republic of Colombia has entered into arrangements to avail itself of foreign enterprise in constructing a canal through its territory. And now, forsooth, the loud proclaimers of the Monroe doctrine of non-interference propose to violate the principle by interfering with the right of Colombia to open a canal. The principle of the Monroe doctrine is not capable of any such application; it is the very bulwark of De Lesseps's enterprise. Originally designed to guarantee to Colombia her sovereign rights over her own soil, it now becomes a hypocritical pretext for invading and crushing her nationality.

Slavery and war are the surviving scourges of barbarism. The Monroe doctrine, having been used to fortify and prolong the curse of slavery, is now to be used to multiply the curses of war, and of war against the progress of peace-promoting commerce.

The sham reasons for defeating De Lesseps being out of the way, there is little difficulty in getting at the real motives of hostility to his project, as evinced by a large portion of the press and embodied in the Congressional resolutions. There are powerful rival interests opposing him, which do not scruple in the use of false pretenses to stir up jealousy and prejudice in the public mind to defeat his enterprise. The Pacific Railroad managers of course oppose further facilities of transcontinental communication; and no one can question that they are at the bottom of much of the hostility to the canal which has found expression in the newspapers. Their case was lately presented in a very candid way by the "New York Evening Mail" as follows: "The people and the Government of the United States have made a tremendous investment in transcontinental railways, that not only bind the Atlantic and Pacific slopes together, but give to the commerce of Europe new and swift channels of communication with the East. In the midst of the terrible uncertainties and fabulous expenditures of civil war, American enterprise, lavishly aided by the Government, undertook the gigantic task of railway-building across the continent. While all branches of industry are still burdened by the taxation imposed during this heroic period, is it quite time for us to favor opening a water-way across the isthmus that would, when completed, become a serious rival for the business that is now partly and gradually recompensing our Government and people? And is it wise at present to aid in opening a channel that will be used by foreign vessels to drive our traffic from the Pacific, as it has been driven from the Atlantic? Are we not entitled to a considerable period of opportunity for reaping the advantages of our costly overland railways, and of the ocean commerce that has been stimulated into a great growth by those railways?"

There is another class of busy operators who are eager for a canal, but in their white-hot patriotism can not endure the thought of its construction by a "foreigner." It must be a purely American affair, in the hands of American contractors, American engineers, and the American Government. So "big a thing," with "millions in it," they think belongs to Americans. And who doubts that in the hands of our business experts it would prove such a bonanza of jobbery, such a placer of plunder as this continent has never seen! Where, indeed, should the series of railroad jobs, of court-house jobs, of State "Capitol" jobs, culminate, if not in a canal costing indefinite hundreds of millions, with indefinite time to build it, with the national Treasury to back it, and so far away as to defy responsibility! And who doubts that those "interests" have been vigilant and active in manufacturing that opposition to De Lesseps which has taken embodiment in the late Congressional resolutions?

In an article contributed by M. de Lesseps to the "North American Review" he says: "It is because the French law is more severe in enforcing the responsibility of directors, thereby more perfectly protecting the rights of shareholders, among whom the United States should be included, that it has been proposed to organize the company under the French law." Could there be a more valid reason for the enterprise being an abomination in the eyes of our "smart American operators," than the fact that the rights of the shareholders would be protected? It is well understood that the experiences of our transatlantic friends in certain of our railroads, our mines, and our repudiated bonds, have led them to be very chary of irresponsible American investments, and that the clamor about the Monroe doctrine and our filibustering designs is intended to frighten away foreign capital from the enterprise of M. de Lesseps.

The sharpers, adventurers, and plotting speculators of the country are a unit against the construction of the Panama Canal by the man who has constructed the Suez Canal, and who defies the world to show that a centime of the funds contributed to it was misappropriated or stolen. Those schemers are well practiced in the arts of hoodwinking the public and of managing Legislatures. Will they be able to force the American Congress to repudiate the most honorable part of the nation's historic policy?

CONDITIONS OF EDUCATIONAL REFORM.

A correspondent from Ann Arbor, Michigan, wants something more explicit and practical from the "Monthly" on the subject of scientific education. He says: "Can not you throw a little more light upon the best collegiate course of education for a young person who designs entering one of the professions of law or medicine? You constantly refer to the value of science as a factor in education and as often vigorously protest against the old or the present classical courses; now, can not you help many who have children to educate, by pointing out the best course? This is a practical question, brought home to thousands of your readers, and it presses upon them for solution. Can not we have something more than glittering generalities, and which will be a guide to those needing the information? Is it not time, in fact, to formulate the best course and to give in detail and in their logical order the studies best fitted for the proper development of the faculties?"

We often have communications like this from zealous and impatient educational reformers, who think there has been talk enough about scientific education, and that it is high time something were done. But they expect too much, and are looking for impracticable things. It is a great mistake to suppose that the object here sought is anywhere to be at once and fully attained. The idea will be slowly and partially realized wherever there is a sufficient number of persons in any community imbued with the proper convictions and feelings to carry it into effect. Such a work must inevitably be gradual, and there will be concessions and improvements just in proportion to the strength and persistence of the demand for them. Our schools, at present, fairly represent the average intelligence and aspiration, and are as good as the people can appreciate or will sustain. A portion of the community—and the numbers are increasing—insist upon more time for science in the lower schools, and more science in place of the classics in the higher schools: both requirements have already been widely yielded. There is a larger provision than formerly in many primary schools for elementary science; and the multiplication of scientific schools in connection with colleges, or independently, and the modification of the old curriculum with better chances for science in many other institutions attest a salutary change in obedience to the growing wants. As the public demand becomes more discriminating and urgent, institutions will improve.

The line of progress, therefore, consists in making existing schools better. They are not to be displaced, but liberalized, and the culture they give made more useful and valuable. There would be no difficulty in forming a rational curriculum, but public ignorance, educated and otherwise, has to be reckoned with in carrying it out, because schools have to be supported. The principles of a better education than we now have are sufficiently understood, and the men are not wanting who could give a receipt for making a college much superior to those now in operation. But, if our correspondent had furnished him a perfect ideal plan, and the whole Johns Hopkins endowment to execute it, he would break down in getting his teachers and trustees, and his establishment would fall to the level of what could be publicly approved. If he merely wants help to construct a liberalized modern curriculum, he will find abundant materials in such works on education as those of Spencer, Bain, and Johnnot.

But there is a good deal of preliminary work to be done before any such ideal can be embodied, and this is the very practical work of enlightening public opinion so as to bring it to bear in improving the existing educational system. There are great impediments to change. Institutions are conservative, and tend to assimilate and subjugate the men who officer them. The noisy reformer is generally quenched by an appointment. His ideals are dissipated in the presence of refractory facts. A great machine system of public instruction, established by the State, and supported by general taxation, is too strongly intrenched to be easily altered. It resists improvement by the inertia of established habits, by official sluggishness, and a foolish pride that will not acknowledge defects. That upon which millions have been spent, and out of which thousands get a living, is sure to be strenuously defended and carefully conserved. Reform must be forced from without, and nothing but a better instructed public opinion can give us better schools.

LITERARY NOTICES.

THE INTERNATIONAL SCIENTIFIC SERIES, NO. XXVIII.

The Crayfish: An Introduction to the Study of Zoölogy, with 82 Illustrations. By T. H. Huxley, F. R. S. Pp. 371. New York: D. Appleton & Co. Price, $1.75.

The purpose of this book will probably be better brought out by an inversion of the title so that it shall read, "The Study of Zoölogy as exemplified in the Crayfish." The work is a contribution to scientific education in the biological field, and conforms to the modern and now well-settled method of passing from the study of concrete details to the investigation of general principles. Instead of beginning with propositions which are the outcome of past inquiry concerning living things as a whole, the student, on the other hand, commences by making himself familiar with some one particular organism, and, having mastered the elementary facts by direct acquaintance and actual knowledge, he then uses this knowledge in extending the range of his studies to other organisms and their relations in the animal kingdom. Professor Huxley has taken the crayfish as the creature best suited for the accomplishment of this object. The information in relation to it is full and valuable, but the book has not been made merely as a monograph on the natural history of this crustacean. Its aim is to lead the student through a large portion of the field of scientific biology, in such a way that he will certainly and thoroughly know the subject; and the crayfish is chosen to attain this end because, all things considered, it is the best-fitted animal to do this. It would be misleading to represent this book as in the ordinary sense a popular one. It undoubtedly contains a good deal of information pertaining to natural history which will be read with general interest, but it was the well-defined purpose of the author in its careful preparation to make a book for biological students that should introduce them aright to the pursuit of their science, and, as the author says, they can only gain its intended advantages by going through the volume, "crayfish in hand." Immense labor has been bestowed upon the work in bringing it into its proper, simplified, and thoroughly methodical shape, and no doubt Professor Huxley could have written a work for the "International Series" with half the effort he has here expended. But he has chosen to avail himself of this channel of communication with different countries to give a new impulse and higher direction to the study of that comprehensive and most important science to which he has devoted his life. Mere book-education and half-knowledge he would, no doubt, admit to be better than nothing, but he would maintain that they are only tolerable as they tend to prepare for genuine and solid scientific acquisitions.

Huxley's "Crayfish" will at once become the text-book of classes which desire to enter the field of natural history by the right path; and it may be very strongly recommended to groups of young people forming clubs or voluntary classes to pursue the study by the method of self-instruction. It is a book, indeed, better suited than any other we know for any young person, with a teacher or without, who wishes to get a right start in cultivating this branch of science.

The Refutation of Darwinism and the Converse Theory of Development; based exclusively upon Darwin's Facts. By T. Warren O'Neill, Member of the Philadelphia Bar. Philadelphia: J. B. Lippincott & Co. Pp. 454. Price, $2.50.

Opposite in every respect to Huxley's book is this volume of Mr. O'Neill upon an aspect of the same subject. Huxley's idea is that, when a man makes a biological book, he ought really to *know* something about the matter—to know it at first hand independently and authoritatively. But this man, who comes forward to put an end to Darwin, has no scientific credentials, but, quite the contrary, he reports himself as a member of the bar. That is, he is an advocate, a professional hireling, who first gets a fee and then argues accordingly. His vocation is not to search for truth by the methods of science, but to win cases by the methods of law-practice. Mr. O'Neill comes into biology as an attorney who proposes to show what dialectics is capable of by refuting Darwin with his own facts, and showing how he can work them all backward and establish a converse theory of development.

We gather, from a very hasty glance at his book, which is all that it is worth, that the author's position is this: He *assumes* the exploded doctrine of the fixity, or what he calls the normal immutability, of species—the old traditional doctrine that prevailed before the rise of modern biological knowledge. As man was created perfect and "fell," so species were created with a primitive "physiological integrity" from which they have become degraded. So the Darwinian progress, proved by Darwinian facts, is but a kind of atavism or reversion upward toward the recovery of lost characters. The book is ingenious from the lawyer's point of view, and makes merry throughout at the expense of Mr. Darwin's gross ignorance of the subjects to which he has devoted his life, but which become luminous in the hands of the man who really knows nothing about them. Another book is promised by the author, and meantime we recommend the present one to all young law-students, that they may see what they are in danger of coming to.

The Geological and Natural History Survey of Minnesota, under the Direction of Mr. N. H. Winchell. 1879.' Pp. 123.

This survey was conducted during 1878 in the northern part of the State, and was devoted principally to the examination of the coast-line of Lake Superior from Duluth to the Pigeon River, for geological and lithological data. It was intended to give especial attention to mining interests, but very few persons were found to have any concern in them, and no actual mining is now done in the State. The zoölogical and botanical investigations were kept in abeyance, or carried only so far as possible without much additional expense. The ornithological section made, however, satisfactory progress, and a good account is given in the report of the plants of the northern shore of Lake Superior. A paper is appended by Mr. C. L. Herrick on the microscopic Entomostraca of the State, with twenty-one full-page plates of illustrations; the first attempt, the author believes, that has been made to describe these little crustaceans as a class.

The Kansas Review. Vol. I., No. 1. November, 1879. Monthly. 75 cents per year.

This succeeds the "Kansas Collegiate" as the periodical of the students of the University of Kansas. Its scope will be more general than that of its predecessor; and it begins by having something to say on scientific and practical subjects. The number before us has signed papers on "Molecules," the comets of the year, and the college course, and the health of college girls.

The Californian. A Western Monthly Magazine. Vol. I., No. 1. January, 1880. Pp. 100. Price, $3 a year.

This is a new periodical, of prepossessing appearance, published by the A. Roman Publishing Company at San Francisco. The first number offers a varied list of articles, among which "The Pacific Coast and Geodetic Surveys" and "Physical and Moral Influence of the Vine" are of scientific interest.

Zoölogy for Students and General Readers. By A. S. Packard, Jr., M. D., Ph. D., Professor of Zoölogy in Brown University. With numerous Illustrations. New York: Henry Holt & Co. Pp. 719. Price, $3.

Dr. Packard has produced a superior text-book for the use of zoölogical students. It is considerably fuller than the ordinary manuals, and provides for pretty thorough study without taking rank among the voluminous and exhaustive treatises. The general reader will find much in it to interest him, but it has been prepared for the advantage of working students; and the author's purpose will only be attained as the learner uses the work to acquire a direct and actual knowledge of zoölogical science. The author thus states the objects he has had in view in preparing his books: "Should this manual aid in the work of education, stimulate students to test the statements presented in it by personal observations, and thus elicit some degree of the independence and self-reliance characteristic of the original investigator, and also lead them to entertain broad views in biology, and to sympathize with the more advanced and more natural ideas now taught by the leading biologists of our time, the author will feel more than repaid."

Problems of Life and Mind. Third Series. By George Henry Lewes. Boston: Houghton, Osgood & Co. 1880. Pp. 500. Price, $3.

This volume contains all the remaining manuscript of the "Problems of Life and Mind" left by Mr. Lewes at the time of his death. Together with a small volume, published a year ago, it forms his contribution proper to psychology, though his "Physical Basis of Mind," in any extended view of the science, also forms a part. In the former volume the aim and scope of the science were considered, and in this the inquiry is carried a few steps into the science itself. The work opens with a discussion of the question of mind as a function of the organism, in which the distinctive views of Mr. Lewes, as to the nature of mind and its relation to the organized body in which its phenomena are manifested, are set forth with clearness, and some of the opposing views criticised with effect. The "sphere of sense and logic of feeling" occupies the author in the second problem of the work, and the like domain of intellect and the logic of signs is considered in the fragment of the remaining problem. Like all the works of this series, the present has the fault of too great diffuseness and unnecessary repetition, but it contains much that is valuable, many suggestive hints, and a good deal of strong thinking. Any examination of the positions taken by the work, or of their relation to the teachings of other psychologists, is impossible here, and nothing further need therefore be said save that students, to whom the subject is of interest, will find this, as all his other works, interesting throughout, and the exposition remarkably lucid.

The Younger Edda. With an Introduction, Notes, Vocabulary, and Index. By R. B. Anderson. Chicago: S. C Griggs & Co. 1880. Pp. 302. Price, $2.

Most people know something of the mythologies and traditions of Greece and Rome, of India and China; but few know anything of those of our Teutonic ancestors, the Norsemen. To bring before English readers the chief features of the theory of creation of these northern peoples, Professor Anderson has undertaken the translation of "The Younger Edda" of Iceland, contained in this volume. Together with "The Elder Edda" this forms a complete system of things. "The Elder Edda presents," says Professor Anderson, "the Odinic faith in a series of lays or rhapsodies," while "The Younger Edda contains the systematized theogony and cosmogony of our forefathers. The two constitute, as it were, the Odinic Bible." The translation is accompanied with very full notes.

Elementary Lessons on Sound. By Dr. W. H. Stone. London: Macmillan & Co. 1879. Pp. 188. Price, 80 cents.

In this little volume are given briefly the main facts of acoustics, with special regard to their relation to music, besides information that is properly intermediate and supplementary to both acoustics and music. It is clearly written and contains in a small compass a large amount of information.

A DICTIONARY OF GERMAN TERMS USED IN MEDICINE. By GEORGE R. CUTTER, M. D., Surgeon of the New York Eye and Ear Infirmary, Ophthalmic and Aural Surgeon to the St. Catherine's and Williamsburg Hospitals, etc. New York: G. P. Putnam's Sons.

THE student of scientific works written in foreign languages encounters many difficulties in the technical terms. They are not given in the ordinary dictionaries, or, if they are, it is as common words with common meanings, and not with any view to scientific correctness. The terms of German science are formed by the composition of native roots, and have no analogous forms in the scientific terms of other languages, and thus frequently offer a double difficulty. The meaning may be thought out, but it is often with risk to accuracy. In the absence of any German medical dictionary corresponding to Dunglison's dictionary, Dr. Cutter has been in the habit for twenty years of writing down the technical terms he met, and their definitions when they could be ascertained. He now publishes the results of these labors in this volume of three hundred double-columned pages of words and their definitions. Its value does not have to be proclaimed.

THEOLOGY AND MYTHOLOGY. An Inquiry into the Claims of Biblical Inspiration and the Supernatural Element in Religion. By ALFRED H. O'DONOGHUE. New York: Charles P. Somerby. Pp. 194. Price, $1.

THEOLOGY and mythology in this work are ranked together, and the writer maintains that they are both to be outgrown with the progress of knowledge. His point of view is thoroughly naturalistic; but the author protests that his book is written in no spirit of hostility to the religious sentiment of mankind. It seeks to get rid of manifest error, and is content with what remains.

POPULAR ROMANCES OF THE MIDDLE AGES. By Sir GEORGE W. COX and E. H. JONES. First American from second English edition. New York: Henry Holt & Co. 1880. Pp. 505. Price, $2.25.

THIS is a book of old mediæval legends and stories, the authors of which nobody knows anything about, and which have been revamped and thrown into the modern market. It is claimed that there is considerable new matter about Arthur and his Knights, and that the whole contents have undergone revision so as to make them acceptable to the taste of the readers of these times. The book contains the story of Merlin, Sir Tristram, Roland, Bewulf, Guy of Warwick, the Volsungs, and many others.

THE AMERICAN ENTOMOLOGIST. An Illustrated Magazine of Practical and Popular Entomology. Edited by C. V. Riley and A. S. Fuller, Washington, D. C. Published by Max Jaegerhuber, 323 Pearl Street, New York. Vol. I., New Series, No. 1. January, 1880. Pp. 24. $2 a year in advance.

PROFESSOR RILEY begins with this number a new series of "The American Entomologist." It will be, as it was before, practical and popular, and devoted not to entomology alone, but also to other branches of science so far as they are collateral or related to entomology. Arrangements will be made for the publication of local lists and purely descriptive matter as it may be furnished, without encroaching upon the space devoted to matter of general interest.

THE AMERICAN MONTHLY MICROSCOPICAL JOURNAL. Conducted by Romyn Hitchcock, F. R. M. S. Vol. I., No. 1. January, 1880. Pp. 20. $1 a year.

THIS takes the place of the "American Quarterly Microscopical Journal," and is intended to be an authoritative and trustworthy periodical for all persons interested in microscopy. Among the subjects which will be treated of at an early date is the detection of adulterations in food, and a translation of Eyferth's "Simplest Forms of Life," by the editor, is promised.

ECONOMICS OF INDUSTRY. By ALFRED and MARY PALEY MARSHALL. London: Macmillan & Co. 1879. Pp. 228. Price, $1.

THIS is an attempt to give in a concise form the outline of the science of economics as laid down by Mr. Mill, and as improved by writers since his time. It consists of a consideration of the laws of the production and distribution of wealth; such subjects as banking, foreign trade, and taxation being reserved for a future volume.

Mémoire sur le Fer Natif du Groenland, et sur la Dolerite qui le renferme. (Memorandum on the Native Iron of Greenland and on the Dolerite which incloses it.) By J. Lawrence Smith, of Louisville, Ky. From the "Annales de Chimie et de Physique," Fifth Series, vol. xvi., 1879. Paris: Gauthier-Villars.

Professor Nordenskjöld found in Greenland during his expedition of 1870 considerable masses of native iron inclosed in the dolerite rocks of Ovifak, in the Island of Disco. Several authors have regarded the metal as of meteoric origin, but Messrs. Johnstrup and Steenstrup, of Copenhagen, have expressed a different opinion, and M. Daubrée, of Paris, is in doubt. The present treatise describes the special studies of the author upon different specimens of the iron, and the conclusions he has derived from them. The iron is found inclosed in solid blocks in the mass of the dolerite. It is of different degrees of purity, some of the specimens being malleable and containing from 80 to 93 per cent. of metal, and others composed of the oxide, or of iron mixed with dolerite. From careful analyses of the specimens and an investigation of their constituents and surroundings, Mr. Smith comes to the conclusion that the iron can not be of meteoric origin, but is of terrestrial production, and originated in the secondary age.

Die Entwicklung des Menschen-geschlechtes. (The Development of the Human Race.) By Dr. Adelrich Steinach, of New York. Basel, Switzerland: Benno Schwabe.

This volume, though it has been the first to appear, is intended to be the second part of a work on the system of organic development. It considers the subject from the Darwinian but not from the materialistic point of view. It first regards man in his place in the world, in the mechanical and teleological aspect, afterward as related to the animals and as related to the individuals of his own species. Under the last head are given discussions of the differences among men and the manner in which they are formed, the hereditability of character and race-features, and the conditions and relations under which the propagation and spread of the race are carried on. The question of the unity of the species is considered as pertinent to this point. The place of man in time forms a second division of the subject; under it are discussed the origin of the race and the light thrown upon it by the earliest relics that have been discovered, and the centers from which the different families have spread. The development of intelligence is treated of in a third division, as related to culture, language, and civilization, the last head including the three subdivisions of development in religious and moral views and regulations, the development of social life and usages, and industrial and scientific efforts. The plan of the work is systematic, the method of treatment and the style are plain and straightforward, the thoughts are richly illustrated with citations of facts, and the manner is modest.

Das Bier und seine Bereitung einst und jetzt. Freie Zymotechnische Studien. (Beer and its Manufacture formerly and now. Free Zymotechnic Studies.) By Hans von der Planitz. Munich: R. Oldenbourg.

The author of this monograph is a young man who received a part of his education in the United States, and has since been associated in scientific and practical operations in connection with brewing works in Germany. He has intended to give all that is known respecting beer, and has embodied in his not very large pamphlet a great amount of historical, technical, and statistical information. He traces the history of beer from ancient Egypt, where it appears to have been first mentioned, to Greece; and discusses the theory that it was carried to western Europe through Armenia, Scythia, and the Celtic and Teutonic migrations. The extent and condition of the manufacture and trade in the middle ages and the usages of the time in respect to them next come under view, after which we are brought down to the present, with its carefully studied processes and the recognition of beer as a staple article of production and consumption in nearly all countries. In this department the fruits of scientific studies are reviewed, the arguments for and against the use of beer are mentioned, and the place it occupies in the economy of the industrial and commercial world is defined. The statistical information is full and detailed, and is given for every country in which beer is an important product, and separately for the different parts of Germany. The pamphlet is full of matter that is interesting even to those who have no other concern in the subject than that of curiosity.

The Berkeley Quarterly. Vol. I., No. 1. January, 1880. Pp. 80. $2 a year.

This is a new journal of social science, published by the Fortnightly Club, at Berkeley, California. Its purpose is defined to be to give public expression to the individual views of members of the Club on topics pertaining to society, to stimulate other persons to investigate such topics, and to furnish a suitable medium for the publication of papers upon them. The January number contains six papers on questions of government, the guidance of society, civil service, and related topics.

The Workshop Companion. New York: Industrial Publication Company. 1879. Pp. 158. Price, 35 cents.

This is a collection of such recipes, rules, processes, and practical hints as will be found of use in the workshop and the household. It has been the aim of the compiler to give only such recipes as he has tested and found reliable, and such information of processes and methods as will meet the needs of those concerned with them. The contents are arranged alphabetically, and as far as possible all information appertaining to any one subject is given under one heading.

Blowpipe Analysis. By J. Landauer. Authorized English edition, by James Taylor and William E. Kay, of Owens College, Manchester. London: Macmillan & Co. 18mo, pp. 161. 1879. Price, $1.50.

The author having been invited to prepare a German edition of Elderhorst's "Manual," his attention was drawn to the fact that in all works on the subject the chemical aspects were subordinated to the mineralogical. He determined to prepare a work from the chemical point of view, following only the peculiar and practical arrangement of Elderhorst. The translation has been printed under the personal supervision of the author.

United States Commission of Fish and Fisheries. Part V. Report of the Commissioner for 1877. Washington: Government Printing-Office. 8vo, pp. 981. With Plates. 1879.

The report embraces, first, the result of inquiries into the condition of the fisheries of the seacoast and lakes of the United States; and, second, the history of the methods adopted for the introduction of useful food-fishes into its waters. The most important single fact ascertained by the Commission during the year was the existence on the whole coast of New England of a large flounder (*Glyptocephalus cynoglossus*), known in Europe as the pole or craig, an excellent food-fish, with the best qualities of the turbot, occurring in abundance and entirely unknown to the fishermen. Special attention has been given so far to the sea-salmon of the Atlantic and Pacific coasts, the land-locked salmon, the white-fish, the shad, the fresh-water herring, and the German carp. Attention will be given to the cultivation of the smelt; and it is hoped, some time, that specimens of the Oriental gourami, a useful fresh-water fish, will be added to the list. The most valuable and by far the largest part of the volume is occupied with the Appendix, more than half of which is taken up with a treatise on the menhaden and its products, amply illustrated, and a large part of the other half with papers on the cod, the cod-fisheries of the Loffoden Islands, and other fisheries of Norway.

Guides for Science-Teaching. — The Boston Society of Natural History is publishing a series of guides for science-teaching, consisting of small pamphlet hand-books, each devoted to a special subject, with illustrations when they are called for. The books are designed as aids to teachers who wish to instruct their classes in natural history—not to be used as text-books—and give, besides illustrations and instructions as to the modes of presentation and study, hints for collecting, preserving, and preparing specimens. "Pebbles," by Professor Alpheus Hyatt, illustrates the way in which a common object may be used in teaching. "Concerning a Few Common Plants," by Professor Goodale, tells of the organs or "helpful parts" of plants, and how they can be cultivated and used in the schoolroom for the mental training of children. Other books are "A First Lesson in Natural History," by Mrs. Agassiz; and "Commercial and other Sponges, and Common Hydroids, Corals, and Echinoderms," by Professor Alpheus Hyatt. Boston: Ginn Brothers.

The Report of the Commissioners of Fisheries of the State of California for the Years 1878 and 1879 records the progress of the efforts to stock the rivers and lakes of the State with valuable fish; and gives also a report by Mr. W. L. Lockington upon the food-fishes of San Francisco. The introduction of salmon into the Sacramento River has been attended with great success. White-fish have thriven in the lakes. Seventy-four catfish from the Raritan River, planted in lakes near Sacramento in 1874, have increased to millions, and furnish an immense supply of food. Sacramento: State Printing-Office.

The Report of the Entomologist of the United States, Department of Agriculture, is largely occupied with the description of insects affecting the cotton-plant, and of the silk-worm and its culture. It also notices a considerable number of insects which are locally destructive to vegetation. Washington: Government Printing-Office.

A Lecture on Petroleum, its History, Commercial Importance, Uses, and Dangers, by P. Schneitzer, Ph. D., of the Missouri State University, embodies a great deal of information on the subject in a small pamphlet. Printed at Columbia, Missouri.

Vowel Theories, by Alexander Graham Bell, describes investigations into the physiology of the formation of the vowels in the throat and mouth, and experiments with the phonograph, which were undertaken by Mr. Bell with reference to their bearing upon Helmholtz's theory of the harmonic composition of the vowel-sounds. New York: William Wood & Co.

"The Industrial News and Inventor's Guide." This is a new journal, edited by Mr. C. B. Norton, and is the organ of the American Industrial Exhibit Company (limited) of New York. It is a monthly magazine of twenty pages quarto, illustrated, the special object of which is stated to be to bring invention and capital together under favorable circumstances and at little expense. The first number is filled with matter relating to the Australian Exhibitions and new inventions. $2 per annum.

The Form of Seeds as a Factor in Natural Selection in Plants, by Robert E. C. Stearns, is an account of studies on the succession of predominant plants in the fields near the University of California, illustrating the advantages which burr-seeded or bearded-seeded plants possess in the struggle for existence.

On Meteoric Fireballs seen in the United States during the Year ending March 31, 1879, by Professor Daniel Kirkwood, is an account of all the meteors observed during the time which were brought to the notice of the author, with the attendant circumstances and phenomena. Many of the descriptions were given by the observers personally; others are gathered from reports made where the meteors were seen.

Indian Corn, by E. Lewis Sturdevant, M. D., though brief, is an exhaustive treatise on the subject. It gives the botanical definition of the plant, its bibliography, its synonyms in all countries, its history and mythology in America, its European history, accounts of its original varieties and its minor variations, of the Indian cultivation, and of the products from the grain, and the classification of varieties, with numerous references to authorities. Among the special questions discussed is whether corn was not known in Europe before Columbus, having been introduced by the Northmen. It seems to have been known in China as early as the sixteenth century. Charles Van Benthuysen & Sons, Albany, N. Y.

PUBLICATIONS RECEIVED.

The Action of the United States Tariff. By Alfred Tylor, F. G. S. New York: G. P. Putnam's Sons. 1880. Pp. 16. 10 cents.

What Christians Believe. By Miles Gaylord Bullock, Ph. D. Syracuse, New York: Thomas W. Durston & Co. 1879. Pp. 218. 35 cents.

The Cause of Humanity. By Courtlandt Palmer. Published for the Society of Humanity, 141 Eighth Street, New York. Pp. 77. 25 cents.

An Epitome of the Positive Philosophy and Religion explanatory of the Society of Humanity, with an Important Letter of Harriet Martineau regarding her Religious Convictions. Published by the Society of Humanity, New York. Pp. 50.

Memorandum in regard to Instruction in the Mechanic Arts. By Edward Atkinson. 1879. Pp. 11.

Publications of the Cincinnati Observatory. No. 5. Micrometrical Measurements of 1,054 Double Stars. Cincinnati. 1879. Pp. 180.

Politics and Schools. By Sidney G. Cooke. Syracuse, New York: Davis, Bardeen & Co. 1880. Pp. 23.

Formation of Ground Ice in the Rapids of the Mississippi. By Dr. R. J. Farquharson. From "Proceedings Davenport Academy of Sciences," 1878. Pp. 6.

The Elements of Education. By Charles J. Buel. Syracuse, New York: Davis, Bardeen & Co. 1880. Pp. 25.

First Annual Report of the State Board of Health of Connecticut, for the Year ending November 31, 1878. Hartford, Connecticut. 1879. Pp. 112.

Suggestions on Rural Hygiene. Circular No. 5 of Connecticut State Board of Health. Hartford, Connecticut. Pp. 11. Illustrated.

List of a Collection of Aculeate Hymenoptera made by S. W. Williston in Northwestern Kansas, pp. 20; The American Bembecidæ, pp. 7; and Generic Arrangement of the Bees allied to Melissodes and Anthophora, pp. 9. By W. H. Patton. From the "Bulletin of the United States Geological Survey." Washington, 1879.

Antiseptics in Obstetrics and Gynæcology. By T. A. Ashby, M. D. Baltimore: Borst & Co., Printers. 1880. Pp. 13.

The Effect of Alum on the Human System when used in Baking-Powders. By Henry A. Mott, Jr., Ph. D. New York. 1880. Pp. 60.

On the Coincidence of the Bright Lines of the Oxygen Spectrum with Bright Lines in the Solar Spectrum, pp. 16; and On Photographing the Spectra of the Stars and Planets, pp. 7. By Henry Draper, M. D. Reprints from "American Journal of Science and Arts," October and December, 1879.

Catalogue of the Pacific Coast Fungi. Published under the Direction of the California Academy of Sciences. H. W. Harkness, M. D., J. P. Moore, A. M. 1880. Pp. 46.

Principal Characters of American Jurassic Dinosaurs. By Professor O. C. Marsh. Part III., with Six Plates. From "American Journal of Science," March, 1880.

Our Public Schools, in their Relation to the Health of Pupils. By J. T. Reeve, M. D. Appleton, Wisconsin. Pp. 27.

Our Schoolhouses. By Professor T. W. Chittenden. Appleton, Wisconsin. Pp. 28.

Annual Reports of the Inspector, Principal, and Physician of the Ontario Institution for the Education of the Blind, Brantford, Ontario, Canada. Printed by C. B. Robinson, Toronto. 1880. Pp. 23.

Report of Work of the Agricultural Experiment Station, Middletown, Connecticut, 1877-'78. By Professor W. O. Atwater, Hartford. 1879. Pp. 174.

Economic Monographs. No. VI. Free Ships. By John Codman. New York: G. P. Putnam's Sons. 1880. 25 cents.

Unity Pulpit, Boston. Sermons of M. L. Savage. Vol. I. No. 12. Morals and Knowledge; No. 13. A New Year; No. 14. Rights and Duties in Matters of Opinion; No. 15. Moral Sanctions; No. 16. The Religious Uses of the Imagination; No. 18. Religion, Public Education, and the State; No. 19. The Church and the Theatre; No. 20. Religion in Business. Boston: George H. Ellis. 1880. 6 cents per copy, or $1.50 a year.

Circulars of Information of the Bureau of Education. Nos. 1, 2, 3, 4, and 5. Washington: Government Printing-Office. 1879.

The Cotton-Worm. By Charles V. Riley, Ph. D. Bulletin No. 3, United States Entomological Commission. Washington: Government Printing-Office. 1880. Pp. 144. Illustrated.

Quarterly Report of the Chief of the Bureau of Statistics. Treasury Department of the United States. For the Three Months ending September 30, 1879. Washington: Government Printing-Office. 1880. Pp. 127.

Bulletin of the United States Geological and Geographical Survey of the Territories. Vol. V., Nos. 1, 2, and 3. Washington: Government Printing-Office. 1879.

Native Flowers and Ferns of the United States. Parts 17, 18, 21, 22, 23, 24, Vol. II. By Thomas Mehan. Illustrated by Chromolithographs. Boston: L. Prang & Co. 50 cents per part.

Around the World with General Grant. By John Russell Young. Parts 3 to 18 inclusive. New York: Subscription-Book Department of the American News Company. 50 cents per part. Pp. 64 each.

Introduction to the Study of Sign-Language among the North American Indians. By Garrick Mallery. Washington: Government Printing-Office. 1880. Pp. 68, with Illustrations.

Annals of the Astronomical Observatory of Harvard College. Vol. XI., Part 2. Photometric Observations. By Edward C. Pickering, Director, aided by Arthur Searle and Winslow Upton. University Press, John Wilson & Son, Cambridge, Massachusetts. 1879. Pp. 124.

Tenth Annual Report of the United States Geological and Geographical Survey of the Territories. By F. V. Hayden, United States Geologist. Washington: Government Printing-Office. 1878. Pp. 546. With numerous Maps and Engravings.

Half a Hundred Songs for the Schoolroom and Home. By Hattie Sanford Russell. Syracuse, N. Y.: Davis, Bardeen & Co. 1879. Pp. 103.

Four Lectures on Early Child-Culture. By W. N. Hailmann. Milwaukee, Wis.: Carl Doerflinger. 1880. Pp. 74. Paper, 25 cents; flexible cloth, 40 cents.

Eyesight, Good and Bad. By Robert Brudenell Carter, F. R. C. S. Illustrated. London: Macmillan & Co. 1880. Pp. 265. $1.50.

Key to Ghostism. By Rev. Thomas Mitchell. New York: S. R. Wells & Co. 1880. Pp. 249. $1.25.

A Handbook of Hygiene and Sanitary Science. By George Wilson, M. A., M. D. Fourth edition. Enlarged and revised. Philadelphia: Lindsay & Blakiston. 1880. Pp. 468. $2.75.

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

Sunshine and Storm in the East. By Mrs. Brassey. With upward of 100 Illustrations. New York: H. Holt & Co. 1880. Pp. 448. $3.50.

A Practical Treatise on Nervous Exhaustion. By Dr. George M. Beard. New York: William Wood & Co. 1880. Pp. 198.

A Forbidden Land. Voyages to the Corea. By Ernest Oppert. With 2 Charts and 21 Illustrations. New York: G. P. Putnam's Sons. 1880. Pp. 349. $3.

POPULAR MISCELLANY.

The Old River-Beds of Middle California.—Old river-beds are found in nearly all countries which have been affected by drift agencies. They are also found in California, but, while in other parts of that State they present general features similar to those of the Eastern States, those of the auriferous slate belt of middle California are entirely different in character and in their situation as respects the present river-beds, and are in some respects unique. In most other countries the present river-beds occupy the same position as the old; the rivers of middle California have been displaced by lava-flows from their former position, and compelled to cut entirely new channels. Instead of cutting these channels at a higher level than the older ones, as has been usually observed, the displaced rivers in California have cut them two or three thousand feet deep in the solid slate, leaving the old detritus-filled channels far up on the dividing ridges. In other parts of the United States the drainage system has remained substantially unchanged since Tertiary times, but in this California region the new drainage system is entirely independent of the old, having the same general direction, but sometimes cutting across it. The detritus in the old river-beds of California is composed of large pebbles and bowlders, instead of the silts generally found, and is capped by lava or other volcanic material. In these observations Professor Joseph Le Conte and Professor Whitney substantially agree. Professor Le Conte has made a further study of the phenomena, and has given his conclusions in a paper in the last number of the "American Journal of Science." The old stream-beds, as they are exposed in the processes of hydraulic mining, are shallow, lowest in the middle and rising to the sides, with such forms ground upon the surface of the bed-rock at their bottom as are always produced by swift currents carrying coarse materials, and are in marked contrast with the deep, sharply V-shaped cañons which characterize the present rivers in the same region. The filling up of the beds consists of a lower course, sometimes a few feet, sometimes many feet in thickness, of a conglomerate of pebbles and bowlders of considerable size, cemented with sand and a blue clay. Above this are alternate layers of pebbles, gravel, sand, and clay, with fragments or trunks of trees of the Pliocene age, and bones of the mammalia of the Pliocene and Quaternary ages, and perhaps human relics. Above the detritus is a capping of volcanic matter, a tufaceous conglomerate, with or without basalt over it. Professor Le Conte accounts for the singular phenomena by a theory, the principal features of which are that the old drainage system began to be formed after the birth of the Sierra Nevada, at the close of the Cretaceous period, and continued to exist through the Tertiary; the Sierra rose during the Glacial period, accumulated great masses of snow and ice and glaciers that were to play a part in filling the beds, and made the courses of the rivers much steeper than they had been before. The eruptions which threw out the volcanic products were preceded by a period of underground heat which melted the accumulated ice-masses. The waters and ice rushing in violent torrents brought down the coarse gravels and masses of rock, and dropped them as they became too great a load for the streams to carry. Afterward came the eruptions, first of ashes, then of lava, which flooded the mountain-slopes and completely obliterated the drainage system. Coincidently there were a considerable elevation of the Sierra range and an increase of the mountain-slope. The glaciers and rivers now began to cut a new system of channels independent of the old ones. They preferred the old divides, for the lava was thinnest or wanting there. As a necessary consequence of the increased elevation, the new channels were cut down to a level below that of the old ones.

Age of the Green Mountains.—Professor James D. Dana gives, in the "American Journal of Science" for March, his reasons for having in the new edition of his "Geology" referred the epoch of the formation of the Green Mountains—in the system of which he includes the whole region between the Connecticut and the Hudson—to the close of the Lower Silurian period. They are, when summarized: 1. That the western half of the region is proved to consist of rocks of the Lower Silurian age, and of one orological system; 2. The schistose rocks of the eastern half, in Vermont, are to a large extent similar to those of the western; 3. The rocks of the central mountain section in Vermont are, in its northern part, identical schists with those on the east and west sides of it; 4. The western border of the region in the Hudson River Valley has its folded or upturned Hudson River (Lower Silurian) slates overlaid unconformably by the Niagara and Lower Helderberg (Upper Silurian) beds; 5. The eastern border of the region in the Connecticut Valley at Bernardston, in Massachusetts, Vernon, in Vermont, and the adjoining part of New Hampshire, has Lower Helderberg beds overlying, unconformably, folded or upturned roofing-slates (similar to those on the western side), the Lower Silurian age of which is not improbable; and at Littleton, in New Hampshire, and on Lake Memphremagog, in northern Vermont, occur unconformable Upper Helderberg (Lower Devonian) beds with fossils; 6. A mountain-individual of folded rocks—which is defined as comprising all the elevations or results of upturning or flexure that were produced over a continuous region in one mountain-making process—is necessarily one of great magnitude. Professor Dana does not consider his theory as established, for a further study of the stratigraphy of the eastern part of the region is required for that, but he believes that the facts, which he reviews in detail, are strongly in its favor.

Gas and the Electric Light.—The question of the feasibility of substituting the electric light for gas is yet far from settlement. The competition will be finally decided by the consideration of the relative expense, regard being also given to the quality of the light afforded. Some experiments which have recently been made for increasing the illuminating power of gas have been attended with satisfactory results. The most effectual devices are those by which a more perfect combustion is secured. By concentrating a number of burners so arranged as to play upon each other, and by improved arrangements for regulating and directing the draught of air upon them, the amount of light has been tripled, and it has been made clearer and more fixed. Burners constructed with this object in view have been tried in London, and found to give a considerable increase of light at a less increase of expense. Other devices, produced by French inventors, promise well. The inventors of electric lights seek either to produce single lights to supplement the defective illumination given by ordinary lights, or to divide the light, so as to make it take the place of gas entirely. The apparatus devised by Messrs. Regnier and Werdemann and Mr. Edison, for the latter purpose, give an agreeable light; but that is only a part of the problem. The difficulty of securing an economical production and supply of electricity remains, and that equally whether we seek to distribute it so that each consumer shall use only what he needs, or to store it in reservoirs of force. Experiments which have been made upon the amount of light produced per horse-power of motive force give greatly varying results. The light of M. Mersanne, with the Lontin machine, is rated at 80 carcels; the Jablochkoff light, with the Gramme machine, at 38 carcels; and Mr. Edison's machine, with 10 of his carbon lamps, at 16 carcels. A comparative trial of the strength of the Jablochkoff and Mersanne lights and gas was made in the latter part of December at one of the railway-stations in Paris. Six of the Jablochkoff lights, ten compound intensive gas-burners, and four Mersanne lights, were used. The brilliancy of the gas-light was to the Mersanne light as 1 to 5·67, and to the Jablochkoff light as 1 to 1·927. On direct comparison, the brilliancy of the Jablochkoff was to the Mersanne as 1 to 3. Roughly, 6 Mersanne lights were equivalent to 18 Jablochkoffs and 34 gas-jets.

Composition and Uses of Celluloid.—Celluloid, which has come into extensive use in the arts, is a species of solidified collodion, produced by dissolving gun-cotton in camphor with the aid of heat and pressure. From a description of its composition and mode of manufacture by Dr. W. H. Wahl, we gather the following: The process of preparing gun-cotton is well known; by it the properties of the vegetable fiber are so changed that it becomes soluble in alcohol and ether, as in making collodion, camphor, and other substances. In the process invented by the brothers Hyatt, gun-cotton is ground in water to a fine pulp; the pulp is then subjected to powerful pressure in a perforated vessel, to extract the bulk of the moisture, but still leaving it slightly moist for the next operation, which consists in thoroughly incorporating finely comminuted gum-camphor with the moist gun-cotton pulp. The proportions employed are said to be one part by weight of the camphor to two parts by weight of the pulp. Any pigments, coloring matter, or other materials that may be adapted to the requirements of the articles into which the product is to be manufactured, may be incorporated at this stage. The mass is next subjected to a powerful pressure, to expel from it the remaining moisture, and incidentally to effect, also, the more immediate contact of the camphor with the pulp. The dried and compressed mass is next placed in a mold open at the top, into which fits a solid plunger, when a heavy pressure applied to the plunger is brought to bear upon the mixture. While thus under pressure, the mixture is heated to a temperature of about 300°, at which temperature the camphor fuses, and, its volatilization being impossible, the melted camphor dissolves, or "converts," the gun-cotton pulp. The process of transformation is rapidly effected when the right temperature is reached, and the product is celluloid. After the mass is taken from the press it hardens and becomes tough and elastic. A noteworthy circumstance is, that a large portion of the camphor appears to be permanently held in the mixture, so that its property of volatilization, when exposed to the air, is arrested. Celluloid is so extensively used as a substitute for ivory that it is said to have seriously affected the business of ivory importers and workers. It has all the strength and elasticity of this substance, and does not warp or discolor with age. It is used in place of tortoise-shell, malachite, amber, pink coral, and other costly and elegant materials, which it is made to imitate very closely. Its latest use is in combination with linen, cotton, or paper, for shirt bosoms, cuffs, and collars.

Experimental Glaciers.—Mr. J. T. Bottomley describes in "Nature" a successful experiment which has been arranged by himself and Mr. D. Macfarlane for constructing a model glacier with shoemaker's wax. A little wooden ravine was prepared, with steep declivities and gentle slopes, and a point where the space was narrowed by projections inward. At the upper end of the ravine a flat place was fixed, on which shoemaker's wax was piled, as snow collects at the upper end of the natural ravine. A supply of shoemaker's wax was put on the top at the beginning of each winter's session, whence a flow of semi-solid material went on steadily during the session, hardly perceptible from day to day, but progressing from week to week and from month to month. Several of the glacial phenomena were beautifully imitated with the wax; among them the more rapid flow of the middle with the less rapid flow at the edges. Little *crevasses* were sometimes formed, though not often, owing to the great effect of temperature on the plasticity of the material. Sir William Thomson, in order to test the qualities of shoemaker's wax as a viscous material, a year ago prepared a large cake of it, at the bottom of which he put some corks, and on the top some bullets. The corks at the end of the year had floated up through the wax, and were coming out at the top, while the bullets had sunk down and come through the bottom; and, while this was going on, the wax was all the time in such a condition as to be excessively brittle to any force suddenly applied.

Source of the Niger.—Information has reached Marseilles of a successful journey to the source of the Niger, which has been made by two men in the employment of the commercial house of M. Verminck, of Sierra Leone. The expedition, it appears, originated with M. Verminck himself, who sent forth two of his clerks, MM. Zweifel and Moustier, with an equipment of surveying instruments, maps, and goods, for the express purpose of reaching the spot on the northern side of the Kong Mountains, some two hundred miles from Sierra Leone, where both Major Laing, in 1822, and Winwood Reade, in 1869, were informed by the natives lay the sources of the "Joliba." The two envoys ascended the river Rokelle to the foot of the mountains, and seem to have met with none of that opposition, from the chief of the important town of Falaba, which defeated the attempts both of Laing and Reade to reach the sources. The crossing of the mountains appears, however, to have been a difficult undertaking, not accomplished without much determination, aided by good luck. The main source was found on the frontier of Kirsi and Koranka; in short, near the place indicated on Major Laing's map.

Animal Heat of Fish.—Surgeon J. H. Kidder, of the United States Navy, made some observations during last summer in connection with the United States Fish Commission at Provincetown, Massachusetts, to test the belief which is still held by many, even scientific observers, that fish are cold-blooded—that is, that they take on the temperature of the water which surrounds them, with no power to resist it, and that they develop little or no animal heat themselves. Observations made in the usual way, by inserting the thermometer into the rectum of the fish, agreed with the generally received opinion, the fish showing in that part but little higher temperature than that of the surrounding water. It was judged, however, that neither the rectum, which is closely exposed to the water, nor the arterial blood, which has passed through the gills where it is exposed and cooled, could have the same value as representing the body-temperature in fishes that corresponding parts possess in mammals and birds, but that the degree of heat actually developed in the life-processes should be sought in the venous circulation and the branchial artery. The fish were accordingly opened as soon as possible after they were taken out of the water, and the bulb of the thermometer was inserted into the cavity of the heart, or the branchial artery. Most of the fishes showed a perceptibly higher temperature than that of the water, rising, in the case of the dog-fish, to 12°. A young dogfish, taken from its mother's oviduct, was 20° warmer than the water. The number of observations was not large enough to warrant a final statement of the degree of animal heat presented by the several fishes, but they are held to prove that fish develop sufficient heat to warm again, to the extent of from 3° to 12°, blood that has been cooled in each circuit to the temperature of the surrounding water. An apparent exception to the general result was offered in the case of blue-fish, which were cooler than the water; but that was supposed to be because they had come up from a greater depth and a colder stratum of water than that on the surface.

Sun-Spots and Rainfall.—Mr. E. D. Archibald writes in "Nature" that, instead of changes in the condition of the sun necessarily affecting every part of the earth in the same way, we have many meteorological analogies which favor the notion that totally opposite effects may arise in different parts of the earth from the action of the same primary causes. Thus, it is generally assumed that the same tropical heat which gives the primary impulse to the desiccating northeast trade-wind of sub-tropical latitudes, furnishes the energy which exhibits itself in the almost constant precipitation under the equator. Any variation in the degree of this heat should consequently affect places in the region of the trades and in the equatorial calm-belt, in a diametrically opposite manner. The great rainfalls of last autumn in England and India were ascribed by some to the sun's emergence from a period of years marked by the rarity of its spots, and shining with increased radiations on the southern oceans; but Mr. Archibald shows that the rainfall of England, between latitudes 50° and 55° north, reached a decided maximum in 1877, a year of extreme spot-minimum, and was very high all through the recent period of unusually marked spot-minimum. A table of the annual mean range of barometric pressure at Calcutta from 1840 to 1878, of which Mr. Archibald gives a summary in his communication, indicates that years of few sun-spots were characterized by higher temperatures, greater wind-velocity, and greater range of barometric pressure than those of many spots.

New Bleaching Preparation.—A method of applying the ordinary bleaching agents (hypochlorites) in a new way has been invented by Count Dienheim de Brochocki, of Paris. Instead of immersing the goods to be bleached in an ordinary "chloride-of-lime" vat, and subsequently scouring, the inventor treats bleaching-powder with an acid, and simultaneously passes air through the mixture, so that chlorine and hydrochlorous acid vapors are mechanically carried off; the resulting gases are passed through an alkaline solution in such proportions as to saturate part or the whole of the alkali, or to supersaturate it at will. The resulting liquid is said to be sufficiently stable to be kept without change for two or three months; it can readily be prepared of a density of 30° Beaumé, and acts as a bleacher without requiring any acidulation, and for many purposes is said to be superior to the ordinary bleaching-vat. The new product, to which the inventor has given the faciful name of chlorozone, is used to a considerable extent in Paris, and works for its manufacture on a large scale have been erected at Warrington.

Effects of Excessive Tea-drinking.—W. J. Morton, M. D., of New York, gives in the "Journal of Nervous and Mental Disease" an account of investigations which he has made on the toxic effects of tea. They were carried on in the cases of five tea-tasters suffering from disease who came under his care, and in observations of his own symptoms during a week in which he subjected himself to special treatment with tea for purposes of experiment. From the whole series of observations he draws the conclusions that—1. With tea, as with any potent drug, there is a proper and an improper dose; 2. In moderation, tea is a mental and bodily stimulant of a most agreeable nature, followed by no harmful reaction. It produces contentment of mind, allays hunger and bodily weariness, and increases the disposition and the capacity for work; 3. Taken immoderately, it leads to a very serious group of symptoms, such as headache, vertigo, heat and flushings of body, ringing in the ears, mental dullness and confusion, tremulousness, "nervousness," sleeplessness, apprehension of evil, exhaustion of mind and body, with disinclination to mental and physical exertion, increased and irregular action of the heart, increased respiration. Each of the above symptoms is produced by tea taken in immoderate quantities, irrespective of dyspepsia, or hypochondria, or hyperæmia; 4. Immoderate tea-drinking, continued for a considerable time, with great certainty produces dyspepsia; 5. The immediate mental symptoms produced by tea are not to be attributed to dyspepsia; 6. Tea retards the waste or retrograde metamorphosis of tissue, and thereby reduces the demand for food. It also diminishes the amount of urine secreted; 7. Many of the symptoms of immoderate tea-drinking are such as may occur without suspicion of tea being their cause, and we find many people taking tea to relieve the discomforts which its abuse is producing.

Antiquity of the Tobacco-Pipe.—The discovery of large numbers of pipes, apparently of considerable age, in Great Britain and parts of the Continent of Europe, has given rise to new and extravagant conjectures as to the antiquity of the tobacco-pipe in Europe. From an article in "The American Antiquarian," by Mr. Edwin A. Barber, we learn that these ancient pipes are very small, and are found in great numbers in the British Isles, where they are known as fairy-pipes, Celtic or elfin pipes, Dane's pipes, Mab pipes, old man's pipes, and Carl's pipes. A number of them have been found so near to Roman remains as to induce the belief that they are Roman relics; but other undoubtedly modern remains have been found in a similar connection. The pipes resemble modern ones in shape, and often bear manufacturers' marks, which make it practicable to estimate their age. The oldest of them are supposed to have been made during the reign of Queen Elizabeth. Probably the oldest illustration of a tobacco-pipe in Great Britain is in a carving on a chimney in the keep of Cawdor Castle, where among the devices are a mermaid playing the harp, a monkey blowing a horn, a cat playing a fiddle, and a fox smoking a tobacco-pipe. This stone bears the date of 1510. Mr. Jewitt suggests, in his "Ceramic Art in Great Britain," that herbs and leaves were smoked medicinally long before the period at which tobacco is believed to have been introduced, and that pipes may have been in use for this purpose before "the weed" was known. British pipes may be classified according to age, with some degree of certainty; by form, as they were developed from exceedingly small pipes with flat heels to larger barrel-shaped pipes, and then to pipes with long handles and pointed spurs. The makers' marks were put on the heels of the oldest specimens, on the bowls of more recent ones, and on the stems of still later ones.

Stammering and its Causes.—M. Chervin, founder and director of the Institution for Stammerers, at Paris, has recently made researches into the prevalence of stammering in France, as shown by the reports of the recruiting officers for the army during the last twenty years, and into the climatic and other influences that are favorable to the development of the infirmity. He has represented the results of his inquiries by a map which exhibits the relative number of stammerers in each of the departments at a glance. The map shows that the country may be divided into two distinct parts, by a line running from Bordeaux to Geneva, on the south of which the number of stammerers is vastly greater than it is on the north of it. The proportion of stammerers to the whole number of young men who have reached the age when they are liable to conscription appears to be about five to one thousand. The districts along the Mediterranean coast seem to be the most liable to the affliction; and it has been found that stammering is also extraordinarily frequent in Piedmont, which has a similar climate and population. M. Chervin attributes the origin of the habit in this region partly to the extreme animation of the speech of the southern people, partly to the hot winds which are the cause of nervous disorders with which stammering may be connected. Stammering may be produced by a sudden fright suffered during childhood. Sometimes the habit comes on gradually, or is developed by association with stammerers. Men appear to suffer more from it than women, as all authors agree, so that out of a hundred stammerers hardly more than ten or twenty will be women. This may, however, only signify that men feel more inconvenience from the evil and notice it more. The reports of the recruiting officers show that the proportion of stammerers is three or four times less in the cities than in the country; a fact that is very suggestive by the side of another which M. Chervin has brought out, that stammerers are most rare where there are the most schools. It is evident that as youth become more accustomed to using their language and learning to distinguish words, to spell and write them, they learn to have a clearer conception of them, to articulate more distinctly, and escape confusion. The great number of stammerers in savage countries has been observed by travelers. It is ascribed to the absence of a knowledge of their language, and to the frequent repetitions of the same syllables which appear in their words.

Investigating the Lightning-Rod.—Delegates were appointed in the summer of 1878, by a number of British societies, to consider the possibility of formulating the existing knowledge on the subject of the protection of property from damage by electricity, and the advisability of preparing and issuing a general code of rules for the erection of lightning-conductors. These delegates have held several meetings, and have already collected a large amount of information. Several of their number are also engaged in forming abstracts of the literature of the subject. In order that their report may be as trustworthy and exhaustive as possible, the delegates ask, through Mr. G. J. Symons, their secretary, for information to be communicated to them by correspondence, on the following points: "Full details of accidents by lightning, stating especially whether the building struck had a conductor or not. If there was a conductor, state its dimensions, construction, mode of attachment to building; whether its top was pointed, distance of its upper terminal from the place struck, nature and extent of the connection between the conductor and the earth, and whether the earth was dry or moist; whether the conductor was itself injured, and whether the conductor or the point struck was the most salient object in the vicinity. Information is also desired, either verbally or by sketches, as to the position of metal spouting and lead roofing relatively to the point struck, and to the conductor. Details of the thickest piece of metal melted by a flash of lightning are much needed. Unimpeachable evidence of the failure of conductors is much desired, as such failures would be extremely instructive."

NOTES.

Mr. James W. Milner, Deputy United States Fish Commissioner, died at Waukegan, Illinois, January 6th, aged forty years. He was born at Kingston, Ontario, grew from the age of five to manhood in Chicago, was, even as a child, exceedingly studious, and is said to have injured his health in this way in early life. He had a special fondness for natural history, and first won attention as a student of science in early manhood by publishing accounts of researches made in Minnesota and adjoining States. In 1871 he received the appointment of Deputy Fish Commissioner, and was afterward, until his death, mainly occupied in the study of fish-culture, on which subject he was considered the best-informed man in the country. Most of his work was done in the West, on the fish of the Great Lakes, his researches on the breeding, mode of life, and food of the white-fish being especially valuable.

Dr. Pasqual Beauville, of Havana, in a report presented to the Havana Committee of the National Board of Health, describes a disease of dogs and horses occurring there which he names acclimation or yellow fever. An ailment with similar symptoms, and called bilious or yellow fever, was described some years ago as attacking the horses in Leith, Scotland. Dr. George W. Sternberg, of the United States Army, gives an abstract of Dr. Beauville's report in the "Bulletin of the National Board of Health," and also the symptoms of the disease observed in Leith, from which he concludes that both refer to one and the same affection, but this was not yellow fever as it occurs in man. He says, "While there are doubtless some striking points of resemblance, the pneumonia and enteritis described by the doctor are so prominent in the record of symptoms and pathological lesions as to give a special character to the disease quite different from that of yellow fever in man."

The committee appointed by the French Minister of Public Instruction has awarded the Volta Prize of 50,000 francs, or $9,500, to Mr. Graham Bell.

An extraordinary prize of 3,000 francs (about $600) has been awarded, by the French Academy of Sciences, to Professor Crookes, F. R. S., in recognition of his recent discoveries in molecular physics and radiant matter.

The Council of the London Entomological Society has offered a prize of £50 (or $250) for the best and most complete life-history of *Sclerostoma syngamus*, supposed to produce the so-called "gapes" in poultry, game, and other birds; and another prize of £50 for the best and most complete life-history of *Strongilus pergracilis*, supposed to cause the grouse-disease. No life-history will be considered satisfactory unless the different stages of development are considered and recorded. The competition is open to naturalists of all nationalities. Essays in English, French, or German may be sent in on or before October 15, 1882.

In a paper read before the French Academy of Sciences on the variations in the force of the action of the heart, M. Marey has observed that the force increases as the heart is full. On this principle he accounts for what takes place when an obstacle to the current of the blood raises the arterial pressure and creates a greater resistance to the action of the heart. The heart slackens its movements; in consequence of this relaxation the ventricle has more time to fill up, and really fills up more; it is then, at the beginning of its new beat, endowed with greater force, and is capable of surmounting a resistance which it could not have overcome if it had been less full.

A singular occurrence is reported to have taken place lately at Leck, in the grand duchy of Nassau. During a severe storm in the night the electric discharge fell into a fish-pond stocked with several species. On the next morning the fish were all found at the top of the water, dead. Their appearance was like that of boiled fish, and their meat fell to pieces when it was handled just like the meat of cooked fish. No hurt, either internal or external, could be perceived; the scales were not bruised, and the swimming-bladder was preserved still full of air. The water was disturbed and muddy at the time, as if it had just been stirred up.

Mr. M. Reynolds, in a paper read before the London Association of Foreman Engineers on practical engine-driving, referred to a source of danger on the locomotive which is, perhaps, more important even than that arising from color-blindness. This is the blinding effect of the glowing white light of the engine-fire, a brief glance into which, he said, renders the person who has looked for a time unable to recognize the colors of the signal-lamps.

The death is announced of Professor David Thomson, for thirty-five years Professor of Natural Philosophy in the University of Aberdeen. He was the author of papers on "The Velocity of the Waves of the Sea" and "On Double-Cylinder Pumping-Engines."

M. Walferdan, the inventor of the minimum thermometer, died in Paris near the end of January, at the age of eighty-five.

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